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(ENTERED DO NOT PRESS NO. 1 OR)
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(3) READ WEEKLY TOTAL
(4) READ TOTAL SALES TO DATE
(5) CALL CUSTOMER RECORD
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Volume 3, Number 4

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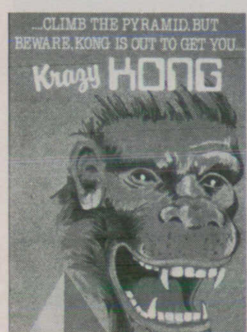

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The TS2040 Printer and ROM Bugs

ZX Users Group of New York

Now that the Timex printer has made its appearance, Sinclair and Timex owners across USA will be adding LPRINT statements to their favorite programs. They will soon find out that there are some bugs in the LPRINT Command. The problem is not in the printer, but in the Sinclair 8K ROM.

ZX users Group of New York, Box 560, Wall St., New York, NY 10005.

The first bug involves the improper printing of numbers between .01 and .00001. The program below, and the output following it, illustrates this.

```
10 LET N=.00001
20 LPRINT N
30 LPRINT .00001
40 LPRINT STR$ .00001
50 LET N$=STR$ N
60 LPRINT N$
.0XYZ1
.0XYZ1
.0XYZ1
.00001
```

As you can see, lines 20 and 40 do not print .00001 correctly. The May 1983 issue of *Syntax* describes this ROM error along with a hardware fix by putting a modified Sinclair ROM on EPROM.

For those of us who do not have access to an EPROM programmer it is necessary to program around the bug. Lines 50 and 60 above show how.

Whenever you LPRINT a number which may be in the range of .01 to .00001, you should first assign it to a string using the STR$ function. Then LPRINT the string. Notice that using STR$ in the LPRINT statement does not correct the problem.

Our ZX Users Group of New York has found some additional bugs. STR$ sometimes does not work right with other string functions in LPRINT statements. For example, the following five LPRINT Commands do not give the expected results, or give error messages when they should not:

LPRINT (STR$ 100)(2)
Gives: 100 (should be 0; also stops with error code 3).

LPRINT LEN STR$ 10
Gives: 100 (should be 2).

LPRINT STR$ 100 AND 0
Gives: 100 (should be blank line).

LPRINT VAL STR$ 100
Gives: 100 (correct, but then stops with error C).

LPRINT CODE STR$ 100
Gives: 100 (should be 29).

The moral of all this is, if something you try to do with LPRINT does not seem to work right, put the expression into a string and LPRINT the string.

We hope that Timex or Sinclair will offer upgraded ROMs to correct these bugs.

try this

8K ROM

Type in the following lines:

```
  1 REM 12345
 10 POKE 16514,62
 20 POKE 16515,101
 30 POKE 16516,237
 40 POKE 16517,71
 50 POKE 16518,201
 60 PRINT AT 11,9;"SYNC MAGAZIN
E"
 70 RAND USR 16514
 80 POKE 16515,30
 90 RAND USR 16514
100 GOTO 10
```

Put the computer in SLOW mode. Press RUN and ENTER. After the program is run once, you can remove lines 10, 30, 40, and 50 and change line 100 to GOTO 20.

Graphics notes:
60: Inverse "SYNC MAGAZINE". Any message can be put here, but use the inverse for best effect.

Our thanks to:
Raymond Marasa
652 Aspen St.
Coquitlam, B.C.
Canada V3J 3W2

Type in the following lines:

```
 5 PRINT " (32 inverse spaces) "
10 PRINT AT 20, RND*30;"."
20 SCROLL
30 RUN
```

Press RUN and ENTER.

Graphics notes:
5: 32 inverse spaces.
10: Inverse period.

Our thanks to:
Scott Brodsky
71 Totman Rd.
Lowell, MA 01854

Type in the following lines:

```
20 FOR N=1 TO 5
30 PRINT CHR$ (36+INT (RND*26+.5));
40 NEXT N
50 PRINT "###";
60 GOTO 20
```

Press RUN and ENTER; press CONT and ENTER for another screen.

Line notes:
20: 5 letters.
30: A random letter A-Z.
50: 3 spaces after each word (8 * 4 = 32 = a full line).

Author's comment: This is the first Basic program I wrote. It is a simple one to produce a screen full of 5 letter "words" made up of letters picked at random. I ran the program and then stared at it and the screen for a long time. Then I decided to send by ZX81 back to be fixed. Then I stared at the screen some more . . .

Our thanks to:
Eric Chandler
228 Arlington St.
Lynchburg, VA 24503

perceptions David Ornstein

INPUT, OUTPUT, and Other Confusing Things

In this issue Perceptions will take up I/O (Input/Output) ports. The fundamental issues are discussed, and a sample method for their application to the TS1000/ZX81 is described.

Introduction

I sit in front of a video terminal. A cursor flashes in a corner of the screen. I press the key labeled ENTER on my computer. From behind, I hear a 'ka-chunk' - the familiar taka-taka-taka of my main printer.

Soon a message appears on the screen. It reads: 'PRINTING COMPLETE. O.K. TO CONTINUE?" I activate the tired muscles in my arm, reach to the keyboard and, extending my index finger, press the Y key. The red LED on one of my disk drives begins to flash!once, twice, and again. Soon they glow constantly.

Then, to my great surprise, the speech section of my computer wakes from its day-old sleep, and begins to recite the alphabet. Next each light in the room begins to cycle: first off, then on, then off, and then back to its original state. The television in the next room goes on, and I hear gunshots from the western movie. I decide to sit back, smoke a cigarette, and go quietly out of my mind contemplating the reason for my computer's apparent loss of its mental faculties.

Contemplation, as usual, leads me nowhere. Pressing, repeatedly, the RESET button seems to have little or no effect on its trip into never-never land. I pull the plug.

The above scenario may sound like an excerpt from HAL's adventures in 2001, but it is not. It is a scene that occurred in my study a few nights ago. Such an occurrence is, admittedly, a rare occurrence in my house. It is, however, more likely to occur in my house than in the average house in, say, a less technically-oriented environment. It usually comes about during the testing of some new feature that I am adding to my computer. Often an I/O port. I scramble a few wires, plug in a board upside—down, or backwards, —whatever.

This time, however, the event was unprecedented: I had a witness. Someone would, finally, be there to back me up when I told my friends what had happened.

My friend (or should I say savior?), a novice in the computer field, was amazed. "What is happening?" and "Can I help?" seemed to the most frequent comments. Once I had cleared up the mystery in my head (a solder bridge), we went to the local coffehouse and discussed music, good coffees, and the events of the evening.

Not surprisingly, the evening's events dominated the conversation. What had happened, he wanted to know. What ensued was an explanation of I/O. Input/Output: those operations which concern the computer's communication, and interaction with the outside world. Soon the cafe closed, and we returned home. The discussion continued, and continued, and continued.... Upon reflection the next day, it occurred to me that the material that we discussed would make a good article. What follows is just that: a summary of that discussion.

What Is an I/O Port?

My friend, having heard me use the term dozens of times that night in conversations with myself, asked me: "What is an I/O port?" An I/O port is a channel, through which, a computer "talks" to the outside world. When a computer wants a printer to print a particular character, it sends, via an I/O port, the code that represents the desired character to the printer. The printer then decodes the charater into the proper internal format (i.e., dots), and eventually yields a character on a piece of paper.

More properly, the computer sends the character that it wants printed to the printer via an output port connected to the computer. Hopefully, a sane printer is listening to the output of that output port. The printer will notice that the computer has sent a character to it, and it will read that character through its internal input port.

Noticing the questioning look on my friend's face, I ordered two more cups of coffee, and dove head on into a detailed description of I/O ports.

Types of Ports

There are two kinds of I/O ports: parallel and serial. Parallel ports are the easiest to understand, so I will tell you about them first.

A parallel port transfers data, usually, eight bits at a time. Eight bits, as you know, comprise a byte—the basic chunk of data in a microcomputer. Larger computers, using parallel ports, may transfer as many as 32 bits in a shot. It depends on how the processor is organized. The Timex/Sinclair 1000 uses an eight-bit microprocessor, the Z80. The Z80 has an eight bit data-bus. A data bus is, conceptually, a series of wires (i.e., eight) that carry around data. The Z80, having eight of these "wires," will use an eight bit I/O port. I reached for an "engineer's best friend"—the napkin.

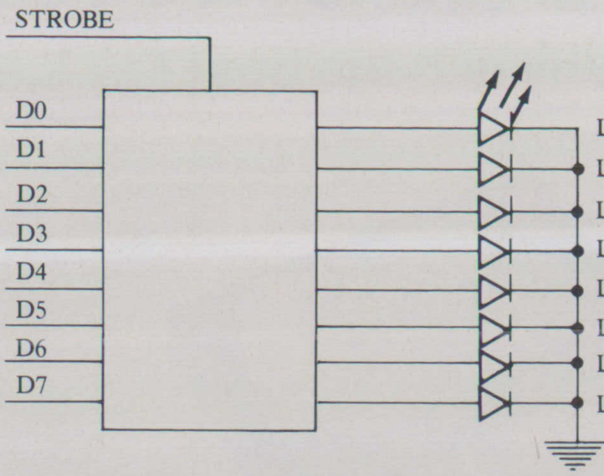
"Let me illustrate," I said. I drew a box with eight lines coming out of each side. One line extended from the top. This is a simple I/O port. (See Figure 1.)

Eight LEDs (Light Emitting Diodes) are

arranged so as to light when their corresponding control lines are activated. To make them all light, the computer must activate all the control lines. It does this by sending an FFh (1111b) to the output port. To turn on LED 2, LED 5, and LED 6, the computer must send a 00110010b.

To send data the computer must place the desired data on its data bus, and activate the STROBE line on the output port. Activation of the strobe line says, in effect, to the output port: "Take what I'm giving you on the data bus. Put it on your output lines, and keep it there—even if I go away. Don't change it until I tell you to (i.e., activate the STROBE line again)." This effect is known as latching. The device (an integrated circuit, probably) that performs the action of latching is known as a latch. When one piece of data is latched, it stays on the output of the latch—until something new is latched.

Figure 1.



Address, Control and Data

When the computer wishes to read data from a keyboard, or read data from a cassette tape recorder, or send characters to a printer, it must know how to tell all those devices (i.e., I/O ports) which one is being talked to. In the case of an average computer, there may be as many as a dozen—or more—output ports. How does it (the computer) know which STROBE line to activate. how does it "activate" them, for that matter?

Let me try to explain by way of an old analogy. Imagine, that the printer to which a character is to be sent lives on a road, He—Mr. Printer, that is—has a mailbox. If he has a mailbox, then he has an address. When Mr. Printer's friend the computer wants to send a message (output) to Mr. Printer, he gives that message to Mr. Mailman (the Data Bus). Mr. Mailman carries the message to Mr. Printer's mailbox (Output Port.) Mr. Mailman then puts it into the mailbox, and strobes it (i.e., he raises the "mail-here" flag). Actually, the mailbox combines both the output port of the computer and the input port of the printer.

When Mr. Printer is ready to read his mail, he goes to his mailbox. He removes the message, and reads (processes/prints) it. He also signals to Mr. Computer that he is ready to receive more mail by lowering the "mail-here" flag. This is a common feature of I/O port arrangements. It says

to the sending device, that the receiving device is ready to accept more data. When the data is sent to the I/O port, the DATA AVAILABLE flag is set. (This was the "mail-here" flag in the above example.) This interaction between output device, and input device is called handshaking.

Without proper handshaking, at least two fatal occurrences are possible. First is the case where the output device is sending data faster than the input device can read and process it. An extreme example might be the case in which a computer is sending characters at a rate of 150,000 cps (characters per second). An average printer can read characters at a rate of approximately 150 characters per second. Every second, the printer would miss 149,850 characters—clearly an unacceptable number. Handshaking solves this problem. The computer reads the DATA AVAILABLE flag that it set (i.e., turned on). It waits until the printer has reset the line before sending another character.

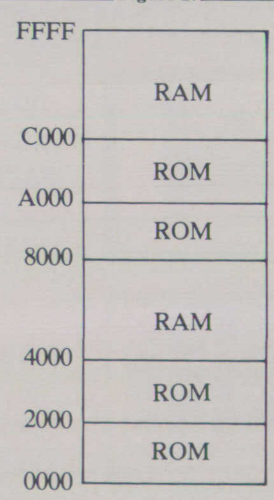
The other problem arises when the computer is reading data from a device that is presenting data slower than the microcomputer is reading. A keyboard is such a device, and a keyboard is a commonly used device indeed. The keyboard has an output port, in this example. When the user presses the W key, the output latch grabs the code for a W, and holds it on its output.

Meanwhile the keyboard is being read by the computer 50,000 times per second. How many times, in that second, do you think the computer will read the key W. Clearly, the synchronization provided by handshaking is critical.

Returning to the issue at hand, a typical microprocessor, such as the Z80, has an eight bit data bus, a 16 bit address bus, and a collection of control lines. These control lines indicate the conditions of the data bus, and the address bus. They dictate, for example, that the 16 bit number on the address bus is the address of a memory location, and that the data on the data bus should be written into that memory location. They might specify that the address on the address bus is currently specifying a particular input port, and that the designated port should place its data on the data bus for the Z80 to read into one of its internal registers.

The address bus, being 16-bit wide. can specify any of 65536 addresses (65536=2**16). The number 65536 is often referred to as 64K. One "K" is 1024 (2**10). The 64K addressing area (address space) of a computer is usually filed with various items: RAM, ROM, and I/O ports. The Timex/ Sinclair 1000's memory space is shown in block form in Figure 2.

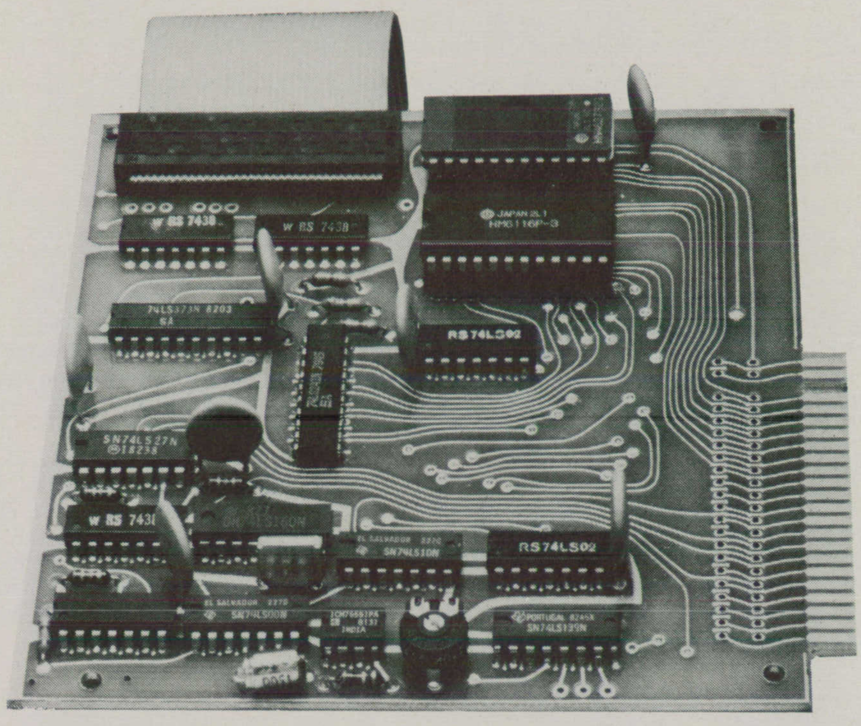
Figure 2.

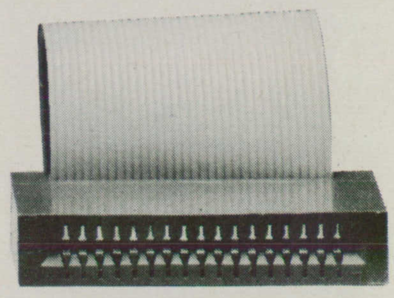


In the next issue, I will continue discussing I/O ports. I will describe a way to open up some of the apparently filled address space of the Timex/Sinclair 1000.

Until next time, same relativistic time period, same non-Euclidian universe.

FLOPPY DISC INTERFACE





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Robotics on a Budget *Bruce C. Taylor*

The Project

A little over a year ago I decided to start building a robot. I had no idea that it would lead to a project fully controlled by a computer. However, as I started reading more about robots and the robotics law, I realized that a true robot had to be a self-contained entity able to operate as independently as possible. At that time I did not even know what a ZX81 was, but, after a few months into the robot project, I bought my first ZX81 computer (the family now owns two). Even then I did not immediately realize the possibilities of ZX81 control. About three months later after reading about the expansion possibilities of the ZX81, I decided to try to combine the ZX81 with the robot.

If you are not interested in such a large computer control project, the hardware, software, and interface methods described here can easily be applied to a smaller project such as a robot arm.

The Robot

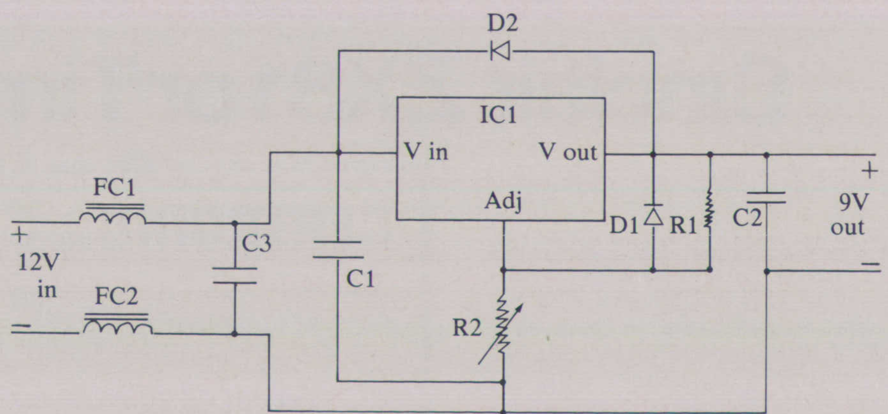
I will not describe the actual construction of the robot in any detail. The design for the robot was based on the *Radio-Electronics* magazine reprint series of articles titled, "Build this robot for under $400."

Although my project robot has many similarities to the RE Unicorn-1 robot, it also has many differences. As complete as the series of articles was, there were many errors and incomplete explanations of the design.

The basic improvements on the physical design are as follows. The diameter of the body was reduced to sixteen inches. It was obvious that a body any wider, with arms added, would have trouble navigating through household doorways and other tight spots. The drive wheels were placed in the front to pull the robot around and aid in traction. This moved the battery to the rear and aided stability. The base was made the same diameter as the body for aesthetic reasons. Although small access doors were located in both the front and back of the base, the required access to the base was achieved by making the entire base plate of the upper body, with turntable, hinge backward to allow full access to the inside of the base. And finally, the computer with expansion board was located on the top and underside of the hinged lid.

To save money and learn as much about the input/output circuitry as possible I purchased the Computer Continuum expansion board and the Zodex RX-81 input/output boards in the bare board form and built them up from components purchased separately. I built up all the other boards and even etched some myself.

Figure 1. Power Supply.



IC1	LM350, 3 Amp adjustable power regulator
D1,D2	1N4002
R1	120 Ohm, 1/4 watt
R2	5K Ohm adjustable pot (10 turn)
C1	.1 MFD, 25V
C2	1 MFD, 15 V
C3	2300 MFD, 33VDC, 50V surge
FC1,FC2	125 uH, 3.5 Amp hash filter choke

Note: Heat sink IC1 well (3 to 4 Sq inches)

Photo 1. Looking through the dome.

Photo 2. Robot lid opened showing ZX81 and power supply.

Photo 3. Dome removed showing 16K RAM, CC expansion board, 2 RX81 I/O boards.

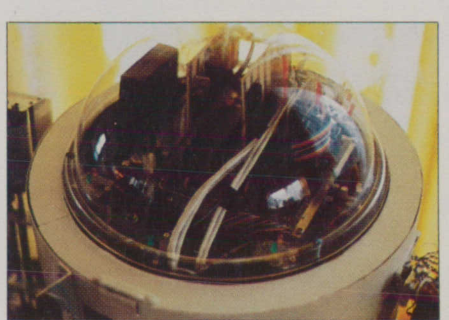
Photo 4. 5 volt DPDT relay board: Wiring side.

Photo 5. Front view of robot.

Photo 6. 5 volt DPDT relay board: Component side.

Photo 8. Transistor switch board: Component side.

Photo 7. Transistor switch board: Wiring side.



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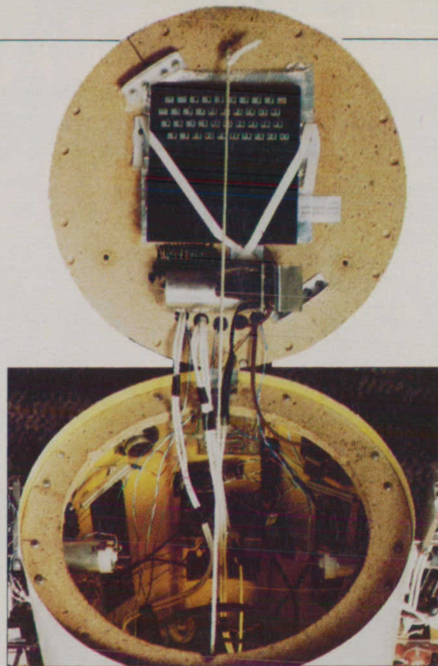

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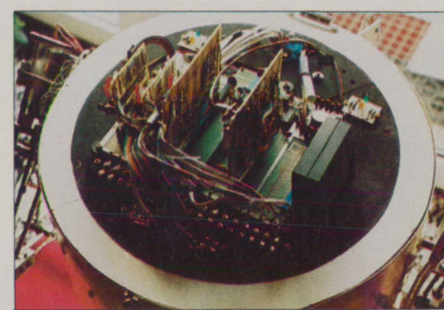

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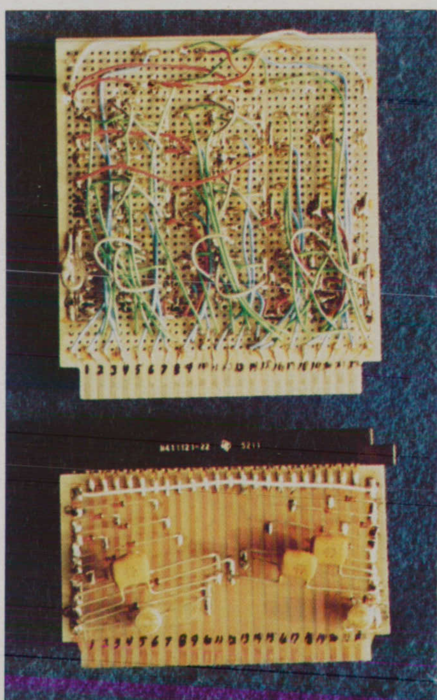

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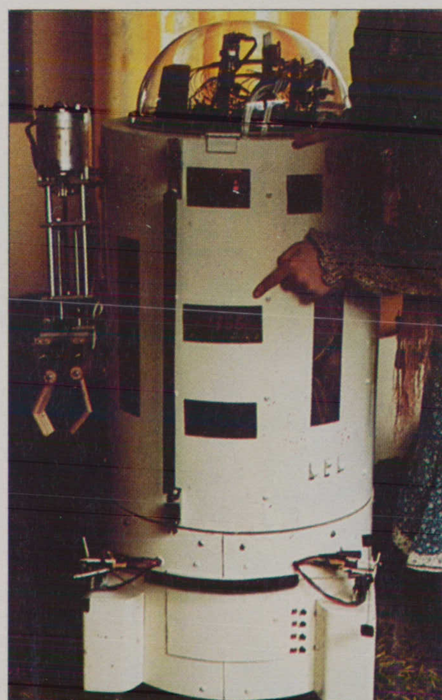

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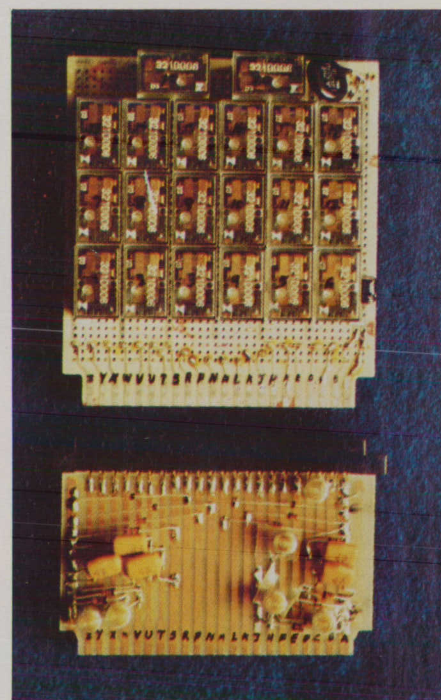

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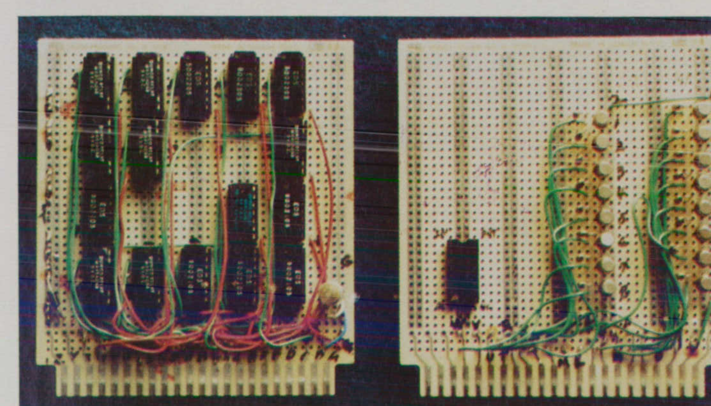

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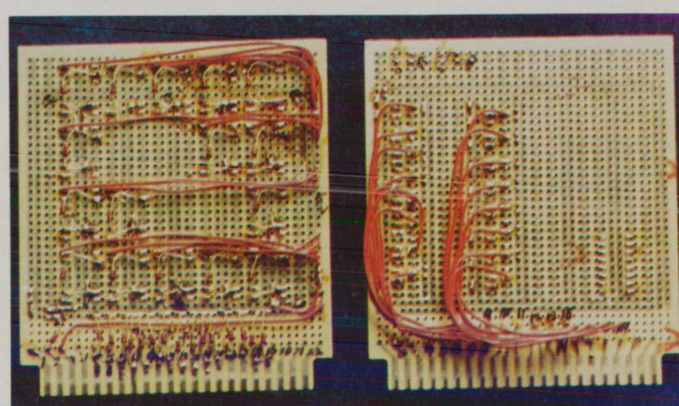

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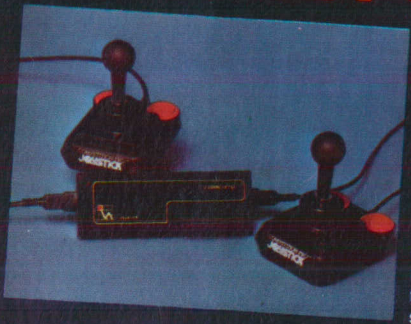

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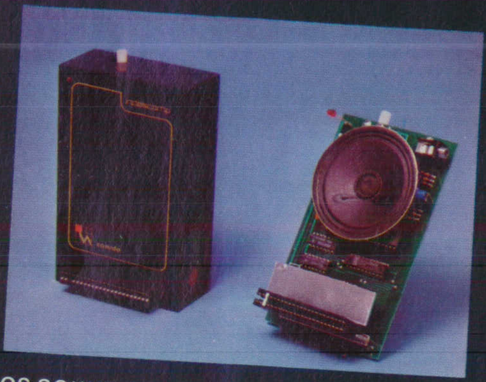

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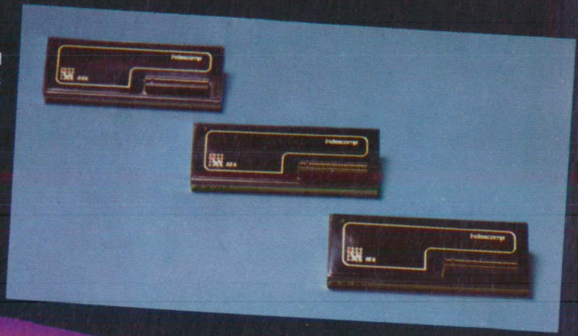

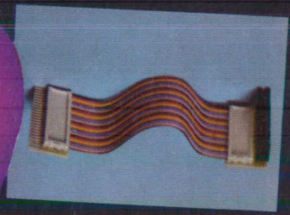

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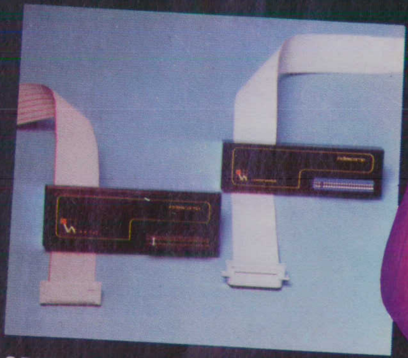

CENTRONICS INTERFACE

Interface to connect the ZX-81 to a serial printer which can work under this norm.
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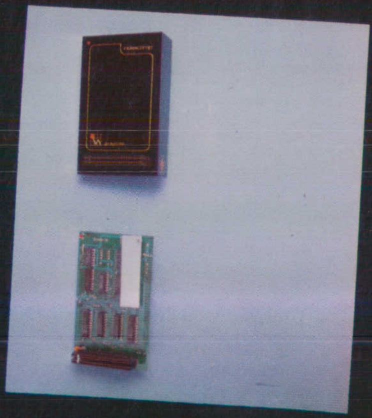

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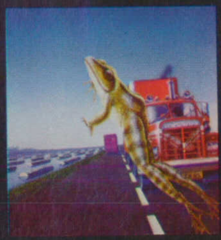

CROAKA CRAWLA $12

Author: **John Field**

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Author: **Marion Stubbs**

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PIONEER TRAIL

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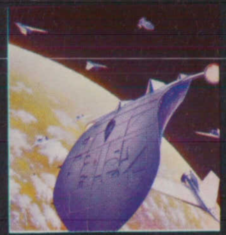

GALAXIANS & GLOOPS

Author: **T. Beckwith**

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QS SCRAMBLE $12

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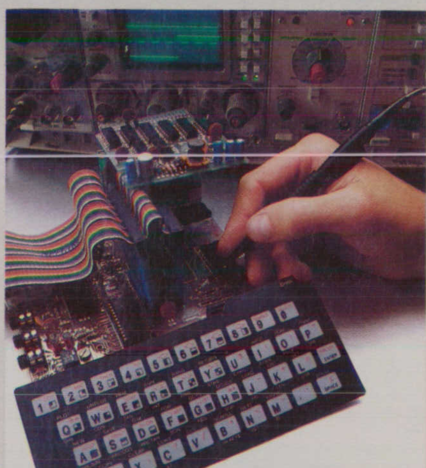

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The Power Supply

The biggest problem on the electronic side resulted from choosing to run everything from a single 12 volt battery. The DC motors and the controlling relays caused problems because the voltage and amperage (frequency) spikes which they generate wreak havoc on the computer. The single battery, originally a large motorcycle battery since replaced with a small car battery, simplified the power management problem.

The final solution to the spike problem had an added benefit for the ZX81 used as the home computer. If you have never tried to use a small computer in Europe, with the "spikey mains" as the British refer to their noisy wall power, you cannot dream of how many ways a computer can bomb. The problem is the same here in West Germany where I am currently living.

The power supply (Figure 1) solved all spike problems. For the robot, the 12 volts in comes from the battery. For a home computer application, the 12 volts in would come from a rectified 12 volt transformer output.

The key to the success of the design is the large can-type capacitor (C3) and the hash chokes. The capacitor is available from Jameco, and the hash chokes were ordered from Mouser. The power supply works so well on my wall-powered ZX81 that all problems previously attributed to LOADing and SAVEing glitches have all disappeared. Also, with the large can capacitor, the house lights can momentarily dim with no effect on the computer.

Figure 2. Relay Functions.

RLY	Function (Motor Drive)
1	Upper body rotate left
2	Upper body rotate right
3	Left drive wheel forward
4	Left drive wheel reverse
5	Right drive wheel forward
6	Right drive wheel reverse
7	(not used)
8	(not used)
9	Left shoulder down
10	Left shoulder up
11	Right shoulder down
12	Right shoulder up
13	(not used)
14	(not used)
15	Left elbow down
16	Left elbow up
17	Right elbow up
18	Right elbow down
19	Right hand close
20	Right hand open

The Control Relays

The heart of the robot control is the 5 volt double pole double throw relays driven by the computer output which in turn activate the 12 volt robot motors and solenoids. The functions of these relays are listed in Figure 2. Although only sixteen are used, the 44 finger circuit boards used are capable of handling up to twenty relays. In my design these relays are double buffered from the computer output drive with both transistor switches and small DIP relays. The 12 volt relays (5 volt coils) are wired similar to the RE reprint layout with some important differences which will be explained later. Figure 3 gives a complete wiring table from the RX-81 output through the 12 volt connections to each motor/solenoid.

I will now quickly walk you through Figure 3 describing the control of relay #1 and then explain each component in more detail.

Relay #1 is controlled by the output of D4 from one of the RX-81 input/output boards. D4 is designated as 1-5 meaning that it is the fifth of eight parallel outputs on the first RX-81 output board. It is

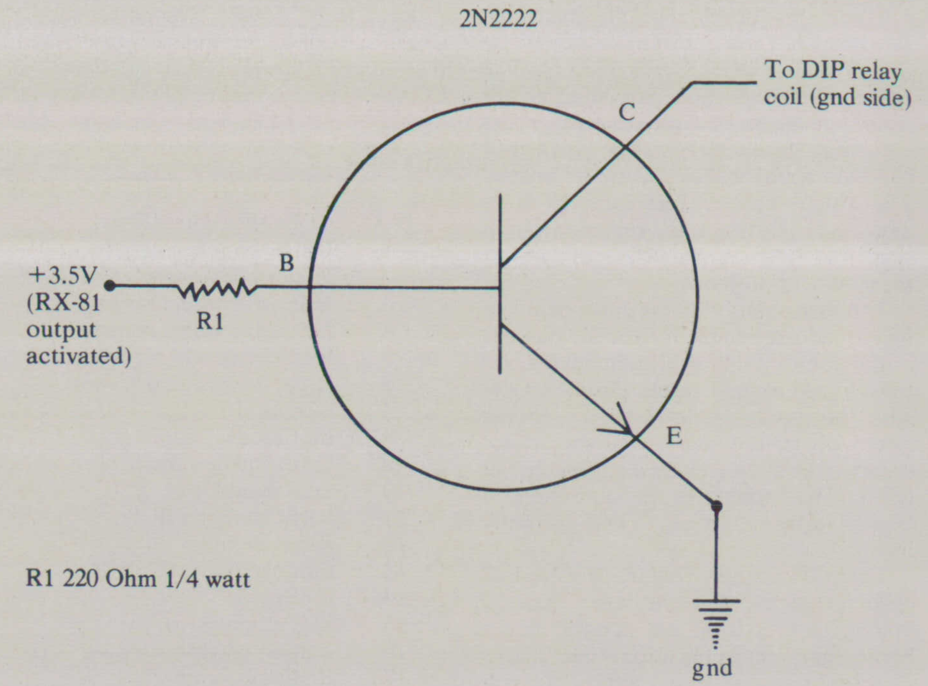
Figure 3. RX-81 Output.

		RX-81 Output		Trans switch		DIP relays		5v relays	
RLY	DO-7	wire color	PC conn	Base (in)	Coll (out)	Coil (in)	Contact (out)	Coil (in)	Contact (out)
1	1-5	blu/sht	10	L	10	L	10	20	W
2	1-6	wht/blu	11	M	11	M	11	17	V
3	1-1	wht/grn	6	F	6	F	6	R	11
4	1-2	grn/wht	7	H	7	H	7	L	12
5	1-3	wht/gry	8	J	8	J	8	6	D
6	1-4	gry/wht	4	D	4	D	5	3	C
7			20	X	20	X	20	21	
8			21	Y	21	Y	21	15	
9	2-1	wht/grn	12	N	12	N	12	N	S
10	2-2	grn/wht	13	P	13	P	13	K	13
11	2-3	wht/gry	14	R	14	R	14	7	E
12	2-4	gry/wht	15	S	15	S	15	2	F
13			22	Z	22	Z	22	19	
14			5	E	5	E	4	P	
15	2-5	blu/wht	16	T	16	T	16	M	U
16	2-6	wht/blu	17	U	17	U	17	8	T
17	2-7	org/wht	18	V	18	V	18	5	J
18	2-8	wht/org	19	W	19	W	19	1	H
19	1-7	org/wht	9	K	9	K	9	18	22
20	1-8	wht/org	3	C	3	C	1	4	10
	Gnd	blu	2	2,B (emitters)		2		A	
+5 volts						3			

RX-81 output board #1 wired as "out 7". RX-81 output board #2 wired as "out 6".

Example: Output DO from board wired as "out 7" is listed above as 1-1.

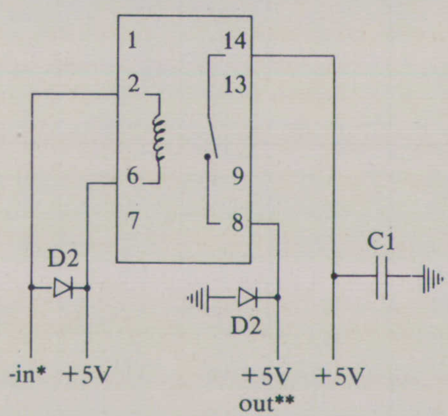
Figure 4. Transistor Switches (Total of 16).



connected by a blue with white stripe wire to finger 10 of a short PC board which is plugged into the circuit loads, depending on the size of the DC motor or solenoid driven.

Large DIP mounted relays of sufficient amperage can be used but they can be expensive ($4-5 each). I found some miniature 6 volt DPDT relays rated at 3 amps which were cheaper and worked quite well. One source is the All Electronics Corp. at only $1.75 each. Sixteen to twenty of these can be packed on a 4 x 5 inch PC board, although the more expensive high amp rated contact DIP relays would not have to be packed so closely.

Figure 5. DIP Relays (16 total).



D2 1N4148
C1 .01 MFD, 10V

**For DIP #1 this would be wired to connector L.
**For DIP #1 this would be wired to connector 10.

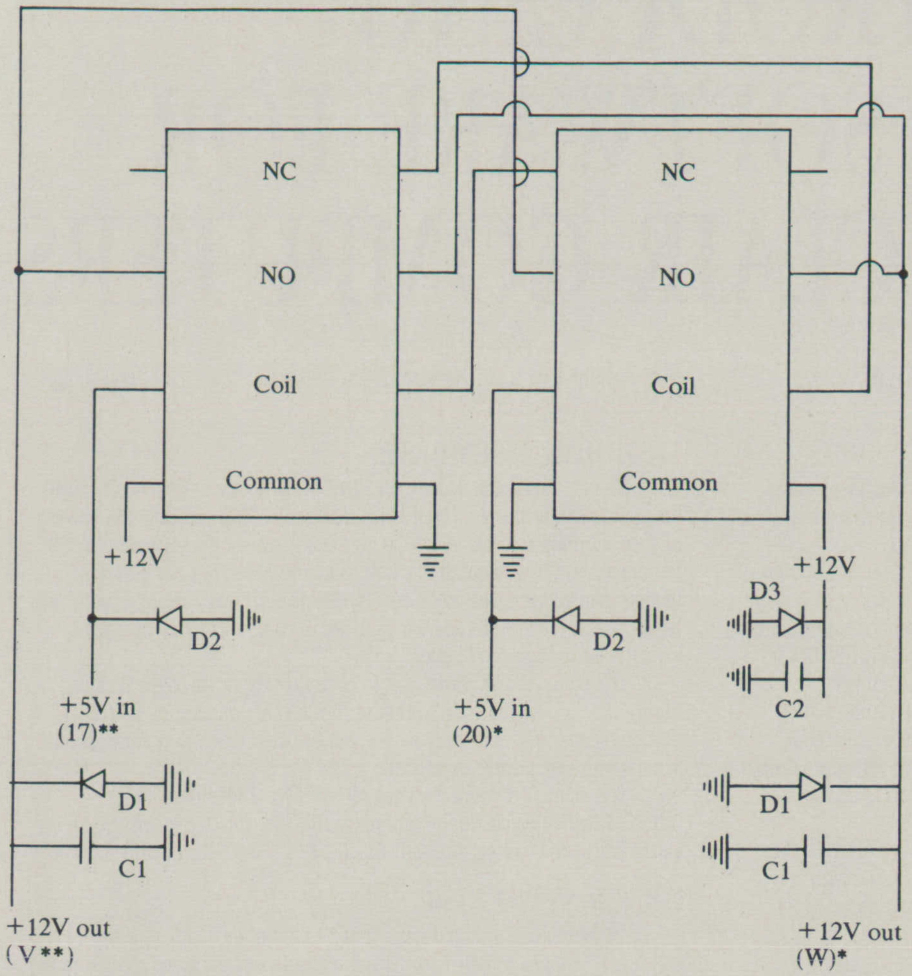
An example of both the forward and reverse relays is shown in Figure 6. They are wired together to prevent accidental shorting of the output to the motor. Each of the two relays for each motor (one for forward and one for reverse) provides opposite polarity power. If you made no special wiring provision, it would be possible to activate both relays at the same time and cause a direct short circuit between +12 volts and ground. Two extra wires between the two relays, along with a modification of a direct hookup, protect against this.

If you look at Figure 6, you will see that the coil input (+5 volts) to the right-hand relay coil (relay #1) will not cause the coil to be activated unless relay #2 (lefthand relay) is not activated. This is because the coil of relay #1 has no ground to complete the circuit unless relay #2 is in the normally closed position. Notice that the ground for relay #1 coil is supplied through the normally closed contact of relay #2. This way, even if both the reverse and forward circuits are activated at the same time, only one will work.

Also note the diode and capacitor protection on these relays. This feature is especially important as the unloading of these relays introduces a lot of unwanted into the electrical circuits.

For some motors in your robot the 12 volt output of the relays in Figure 6 will be hooked directly to the motor leads. However, you may wish to install limit switches on the mechanism of some motor drives such as the arm elbow motor. The limit switches are normally closed

Figure 6. 5 Volt DPDT Relays (16 total).



D1 1N4002
D2 1N4148
D3 1N5401
C1 .01 MFD 25V
C2 22 MFD 35V

NC = Normally closed contact.
NO = Normally open contact.

*Wired to this connector if relay #1.
**Wired to this connector if relay #2.

contact microswitches. A simple but effective limit switch circuit using two diodes and a four terminal, terminal strip is depicted in Figure 7. If you happen to get it wired backwards (50/50 chance), just reverse either the 12 volt input leads or reverse the motor output leads.

Input Stimuli

Before we turn to software, a few words about input stimuli to the input board. First, the input board is the same board that is used for output, the Zodex RX-81 in this case. The RX-81 provides eight input lines and a ground. To input a signal to D0, or as I refer to it, 1-1 (input line #1 of RX-81 board #1), you just connect the input line to ground.

For my robot I installed normally open connect microswitches to the exterior of the robot with spring wire extensions covered with foam rubber pads. The bumper switches include one as a front bumper, one as a right bumper, and one as a left bumper. I actually installed two sets of two front bumper switches each, one set with a spring wire horizontally between them and another set with a spring wire vertically between them. This arrangement gives a larger striking area if the robot runs head on into something. The obvious expansion of the input switch system would be the addition of other types of sensors such as an ultrasonic range measuring system, like the one from a Polaroid camera focusing system, available for about $130.

An alternate way to accept input commands to the computer is to wire the external microswitches sensors as keys on the ZX81 keyboard. This method works, but it is not totally satisfactory. The computer can be set up to scan the keyboard for specific key inputs, but the problem arises when two keys (or micro switches) are closed at the same time. This can easily happen if the robot works its way into a corner and hits the front and side sensors together. The computer will not normally accept any keyboard input if this happens and it could even be seen as an illogical input and blow the program.

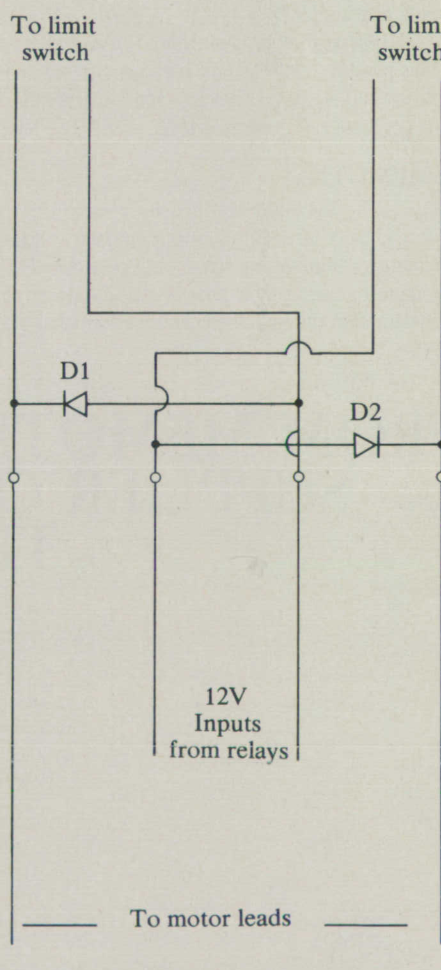
With sensors wired to the RX-81 paralled input board a program can be written to accept any combination of simultaneous sensor inputs at the same time, and recognize them. More on that in the software explanations.

Writing the Software

When your robot motors and bumper switches are wired up to the ZX81 computer as described, you are ready to start writing software to "control the world" or at least the world of your robot. All programs are for 8K ROM. The second listing will require 16K RAM.

The data sheet that comes with the RX-81 explains a few programming instructions to get you started, but my programs written for direct robot control will be explained in detail. All programs start with the line of machine language in the REM statement (do not forget to delete the first REM statement containing

Figure 7. Limit Switch Hookup.



D1, D2 1N4002

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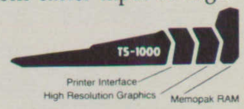
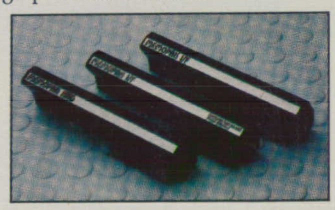
If you own a TS-1000 or ZX-81 computer and want to bring out the power within it, you'll want Memotech. From easier input to high quality output and greater memory, Memotech makes the add-ons you demand. Every Memotech peripheral comes in a black anodized aluminum case and is designed to fit together in "piggy back" fashion enabling you to continue to add on and still keep an integrated system look.



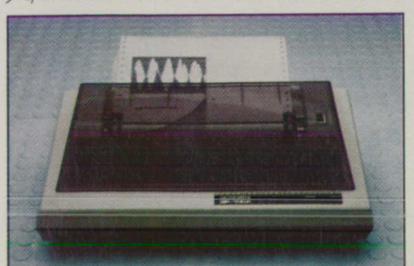
MEMOPAK RAM All Memopak RAMs are directly addressable, user transparent, are neither switched nor paged and no additional power supply is required. You can also choose the Memopak RAM which is just right for your needs. From economy to power. **16K RAM** The Memopak 16K RAM is the most economical way to add memory to your TS-1000. It is fully compatible with the Timex or Memotech 16K RAMs to provide you with up to 32K of RAM. The 16K RAM also offers additional add-on capabilities through its "piggy back" connection. **32K RAM** The 322K Memopak enables you to execute sophisticated programs and store large data bases and like the 16K RAM is fully compatible with Timex's or Memotech's 16K RAMs to give you a full 48K of RAM. **64K RAM** The 64K Memopak is powerful enough to turn your TS-1000 into a computer with capabilities suitable for business and educational use. It accepts such BASIC commands as 10 DIM A (9000). **MEMOCALC** Memocalc, our spreadsheet analysis software, enables TS-1000 users to perform complex number crunching routines with ease. With the 64K RAM a table of up to 7000 numbers with up to 250 rows or 99 columns can be specified. Quick revisions can be achieved by entering new data to your formula.

MEMOTECH KEYBOARD For ease of operation, the Memotech keyboard is a high quality standard typewriter keyboard, with TS-1000 legends. The keyboard is cable connected to a buffered interface which is housed in a standard Memopak case and plugs directly into the back of the TS-1000 or other Memopaks. **MEMOPAK HRG** The Memopak High Resolution Graphics, with up to 192 by 248 pixel resolution, enables display of high resolution "arcade game" style graphics through its resident 2K EPROM, programmed with a full range of graphics subroutines.

CENTRONICS PARALLEL AND RS232 INTERFACES Memotech's Interfaces enable your TS-1000 to use a wide range of compatible printers. The resident software in the units gives the complete ASCII set of characters. Both Memopak Interfaces provide lower case character capabilities and up to 80 column printing. The RS232 Interface is also compatible with modems and terminals.



SEIKOSHA GP 100A PRINTER The Seikosha GP 100A uses a 5x7 dot matrix printing format with ASCII standard upper and lower case character set. Printing speed is 30 characters/second with a maximum width of 80 characters. The printer uses standard fanfold paper up to 9-1/2 inches wide. The GP 100A is offered as a package including cable and interface. Other printer packages are also available through Memotech.



ORDER AT NO RISK. All Memotech products carry our 10 day money back guarantee. If you're not completely satisfied, return it within ten days and we will give you a full refund. And every Memotech product comes with a **six month warranty**. Should anything be defective with your Memotech product, return it to us and we will repair or replace it free of charge. **Dealer inquiries welcome.** To order any Memotech product use the order coupon or call our toll-free number **800/662-0949.**

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MEMOTECH
CORPORATION

7550 West Yale Avenue, Denver, Colorado 80227, 303/986-1516, TWX 910-320-2917

Mail To: Memotech Corporation, 7550 West Yale Ave., Denver, CO 80227
Code: SY-78

	Price*	Qty.	Total
16K RAM	$ 49.95		
32K RAM	99.95		
64K RAM	149.95		
Memocalc	49.95		
Keyboard with Interface	99.95		
High Resolution Graphics	99.95		
Centronics Parallel Interface	74.95		
RS232 Interface	99.95		
Printer Cable	19.95		
GP 100A Printer Package**	399.00		
Shipping and Handling	4.95		$ 4.95
Tax (Colorado residents only)			
TOTAL			$

*All prices quoted in U.S. dollars. Prices and specifications subject to change without notice.
**Please add an additional $5.00 for printer shipping charges.

☐ Check ☐ MasterCard ☐ Visa

Account No. ____________ Exp. ____________

____________ (____)________
Name Phone number

Address

City State Zip

Figure 8. Software Commands.

Function	Relay	Output	POKE A,	POKE B,
Body left	1	1-5	16	7
Body right	2	1-6	32	7
L wh fwd	3	1-1	1	7
L wh rev	4	1-2	2	7
R wh fwd	5	1-3	4	7
R wh rev	6	1-4	8	7
L sh dn	9	2-1	1	6
L sh up	10	2-2	2	6
R sh dn	11	2-3	4	6
R sh up	12	2-4	8	6
L el dn	15	2-5	16	6
L el up	16	2-6	32	6
R el up	17	2-7	64	6
R el dn	18	2-8	128	6
R hand close	19	1-7	64	7
R hand open	20	1-8	128	7

Switch	Input	IF IN=	POKE B,
Front bumper	1-1	1	7
Left bumper	1-2	2	7
Right bumper	1-3	4	7
Right palm	1-8	128	7

(Note: A = 16522 and B = 16524)

the program name before running the program) followed by POKE 16517, 79.

To activate an output line you first POKE the binary number for the line, then POKE the number of the output board (if you have more than one board) and the activate the command with an OUT USR statement. For example, if you wanted to activate output line #3 on an output board wired as "OUT 7" you would write the program as follows:

100 POKE 16522,4
(addresses line #3)
110 POKE 16524,7
(addresses board wired as OUT 7)
120 LET OUT=USR 16521
(activates command)

As listed in Figure 8, this would make the right wheel move the robot forward. To make the right and left wheels go forward use the following lines:

130 POKE 16522,5
(addresses line #1 and #3 together by adding their binary numbers 1 + 4)
140 POKE 16524,7
(addresses board wired as OUT 7)
150 LET OUT=USR 16521
(activates command)

To turn these motors off, POKE 0, as follows:

160 POKE 16522,0
(deactivates all output lines)
170 POKE 16524,7
(addresses board wired as OUT 7)
180 LET OUT=USR 16521
(activates command)

Memory Saving Shortcuts

As you might have gathered from Figure 8, there are some memory saving shortcuts to this programming. If you add the following LET statements earlier in the program, you save memory and make the program statements easier to type into the computer.

```
10 LET A=16522
20 LET B=16524
30 LET C=16521
```

The above lines 100-180 can now be shortened to:

```
100 POKE A,4
110 POKE B,7
120 LET OUT=USR C
130 POKE A,5
140 POKE B,7
150 LET OUT=USR C
160 POKE A,0
170 POKE B,7
180 LET OUT=USR C
```

Other refinements are possible to further save program steps. For example, lines 140 and 170 can be omitted because location B (16524) remains POKEd throughout the sequence. If you change from the OUT 7 board to a second board wired as OUT 6 and back again, the POKE 16524 step would have to be included each time so that the proper board would be addressed.

NOW. A TS1000/ZX81 PUSH-BUTTON KEYBOARD FOR UNDER $20.00.

At last there's a really cheap but efficient way of ironing out the TS1000/ZX81's only real bug: its keyboard. The Filesixty Buttonset offers

■ A full-travel calculator-type moving keyboard for only $19.50.

■ Installed in seconds. The peel-off adhesive backing means you just register into position and press.

■ No messy labels, dismantling or soldering.

■ 3 groups of colour keys to pick out shift, numerals and newline.

■ Precision moulded in ABS to match your TS1000/ZX81, with contrasting legends for maximum legibility.

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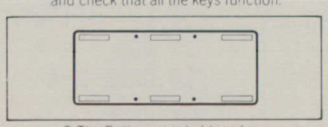
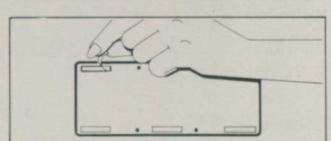
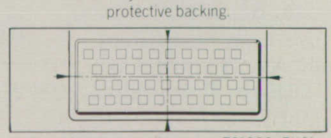
1. Make sure the original keyboard is clean and check that all the keys function.



2. The Buttonset is held in place by self-adhesive pads.



3. So all you do is remove the protective backing.



4. And place it centrally on your TS1000/ZX81.

Cheques/money orders made payable to Filesixty Ltd.

Please send me ______ (qty.) Buttonset(s) at $19.50 each (inclusive of postage & packaging).

Total $ ______ BLOCK CAPITALS

(U.S. DOLLARS ONLY)

Name ______

Address ______

______

State ______

Zip ______

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USA2 SYNC

Parts List

(Parts with common part numbers have been omitted from this list, i.e., transistors, ICs and resistors)

Power Supply

2300 MFD, 33VDC capacitor. Jameco # 2300@33V.

5k ohm adjustable pot (10 turn). Mouser # 593-830P.

125 uH, 3.5 amp Hash Choke. Mouser # 542-5252.

DIP Relay Board

5v BIP relay. Mouser # 518-5002105.

PC board. Hobby board. Digi-key # K160-ND.

5 volt DPDT relay board

5v DPDT relay. All Electronics # FRLY-6.

PC board (Same as DIP relay board above).

Transistor switch board

PC board (same as PC board above).

Circuit board holder

Edgeboard connectors. Digi-key C1-22.

Intermediates connector (Photo 2)

PC board (same as PC board above).

Edgeboard connectors (one connector can be cut into the size shown). Digi-key # C5-50.

Computer Continuum expansion board

If the bare board is purchased, a parts list is provided.

Zodex RX-81

If the bare board is purchased, a parts list is provided.

Addresses:

Jameco Electronics, 1355 Shoreway Road, Belmont, CA 94002.

Mouser Electronics, 11433 Woodside Ave., Santee, CA 92071.

Digi-key Corporation, P.O. Box 677, Thief River Falls, MN 56701.

All Electronics Corp., P.O. Box 20406, Los Angeles, CA 90006.

Computer Continuum, 301-16 Ave., San Francisco, CA 94118.

ZODEX, East Hill, Oakham, MA 01068.

Robotics Note

The *Radio-Electronics* series on building a robot is available in reprint form for $12 plus $1 s&h from: Radio-Electronics, Reprint Dept., 200 Park Ave. South, New York, NY 10003. Readers who want to communicate with the author Bruce Taylor may do so in care of *SYNC*.

Test Program

An example of a test program is provided in Listing 1. This program activates a single output line and then stops. If you enter CONT, it will then turn the output line off and stop again. Enter CONT, and it will activate the next output line and so forth, repeating the process.

The input line activation is a little simpler. You first ready the input for activation and then use IF statements to look for the proper input to activate a response. For example:

500 LET IN=USR 16514

(readies input for activation)

510 IF IN=1 THEN GOTO 100

(if input line #1 is activated, the program jumps to line 100)

If more than one input board is used, a POKE 16524 line would have to precede the USR line to identify the board in accordance with how it is wired. In my robot only one board is used for input as eight input lines are more than enough. Also, the same memory saving techniques can be used

LET F=16514

A sample routine to scan for inputs is as follows:

```
900 LET IN=USR F
910 IF IN=1 THEN GOTO 100
920 IF IN=2 THEN GOTO 200
930 IF IN=4 THEN GOTO 300
940 GOTO 900
```

Listing 1.

```
  1 REM "RX81"
  2 REM <=▘J ▞ TAN Y PEEK ▞TAN
 10 POKE 16517,79
 20 LET A=16522
 30 LET B=16524
 40 LET C=16521
 50 POKE A,1
 60 POKE B,6
 70 LET OUT=USR C
 80 STOP
 90 GOSUB 530
100 STOP
110 POKE A,2
120 POKE B,6
130 LET OUT=USR C
140 STOP
150 GOSUB 530
160 STOP
170 POKE A,4
180 POKE B,6
190 LET OUT=USR C
200 STOP
210 GOSUB 530
220 STOP
230 POKE A,8
240 POKE B,6
250 LET OUT=USR C
260 STOP
270 GOSUB 530
280 STOP
290 POKE A,16
300 POKE B,7
310 LET OUT=USR C
320 STOP
330 GOSUB 570
340 STOP
350 POKE A,32
360 POKE B,7
370 LET OUT=USR C
380 STOP
390 GOSUB 570
400 STOP
410 POKE A,64
420 POKE B,7
430 LET OUT=USR C
440 STOP
450 GOSUB 570
460 STOP
470 POKE A,128
480 POKE B,7
490 LET OUT=USR C
500 STOP
510 GOSUB 570
520 STOP
530 POKE A,0
540 POKE B,6
550 LET OUT=USR C
560 RETURN
570 POKE A,0
580 POKE B,7
590 LET OUT=USR C
600 RETURN
```

Program to Move the Robot Forward

Listing 2 is a portion of the program that is currently in my robot. It moves the robot forward (R + L wheel fwd), while scanning for hits on the microswitch sensors in the form of inputs. If the right bumper input is activated, the robot stops its forward motion, backs up, turns to the left about 30 degrees and continues forward, again sensing for bumper inputs. The sequence is similar for a left bumper input except that it turns to the right about 30 degrees before continuing.

The sequence for a front bumper hit is a little different in that a random number generator is used so that 50* of the time the robot turns right 60 degrees and 50* of the time it turns left 60 degrees before continuing forward. A counting step is also included as part of the input scanning routine so that the robot moves forward for about nine seconds and then generates a random number between zero and one. One third of the time it will stop and go into a body rotating and arm demonstration subroutine.

Timing Techniques

Several timing techniques are used in the program. PAUSE is a good technique when interruption is not required such as in arm movements, where there is no danger of hitting or running into something. The FOR-NEXT loop is a good technique for input scanning when there is a possibility of a collision with another object. A counting technique as a loop also works well in this situation.

The Expansion Boards

Do not be scared off by this project if you are not willing to go the full expansion route with a board such as the Computer Continuum product. The Computer Continuum expansion board was chosen because of its 3 amp capacity for 5 volt supply as additional circuits are added to the robot.

The Zodex RX-81 board (also available assembled as a "Control Board for 8 devices") can be plugged directly into the ZX81 bus just as the printer and 16K RAM are plugged in. If you want to add more boards, a simple Y connector will do the trick.

However, if you want to use the Computer Continuum expansion board, you must know which of the two versions of the board you have, neither of which can be used as I have described without some modification. The earlier version of the board will accept the Zodex board plugged directly into an expansion edge connector (50 pin, .1 inch centers) soldered to the CC board, but the logic will not work without an additional simple decoder circuit you will have to build. The Sinclair printer will not work without this decoder circuit either.

The newer version of the CC expansion board comes with the decoder circuit built into the board, but the expansion pad pinout has been reversed so that the Zodex board can no longer be plugged directly onto the CC board. The Zodex board can be plugged onto the bus connection for the 16K RAM, but then you have to work out another location for the RAM.

Listing 2.

```
   1 REM "RX81"
   2 REM <=■J ■ TAN Y PEEK ■TAN
  10 POKE 16517,79
  20 GOTO 2060
  30 POKE A,0
  40 POKE B,7
  50 LET OUT=USR C
  60 PAUSE 30
  70 POKE A,10
  80 GOSUB E
  90 PAUSE 70
 100 GOSUB D
 110 IF RND<.5 THEN GOTO 140
 120 POKE A,6
 130 GOTO 135
 140 POKE A,9
 150 GOSUB E
 160 PAUSE 37
 170 GOSUB D
 180 GOTO 2210
 190 POKE A,0
 200 LET OUT=USR C
 210 PAUSE 30
 220 RETURN
 230 LET OUT=USR C
 240 RETURN
 250 POKE A,0
 260 POKE B,7
 270 LET OUT=USR C
 280 PAUSE 30
 290 POKE A,10
 300 GOSUB E
 310 PAUSE 37
 320 GOSUB D
 330 POKE A,9
 340 GOSUB E
 350 PAUSE 5
 360 GOSUB D
 370 GOTO 2210
 380 POKE A,0
 390 POKE B,7
 400 LET OUT=USR C
 410 PAUSE 30
 420 POKE A,10
 430 GOSUB E
 440 PAUSE 37
 450 GOSUB D
 460 POKE A,6
 470 GOSUB E
 480 PAUSE 5
 490 GOSUB D
 500 GOTO 2210
 510 STOP
 520 REM RANDOM SELECT
 530 IF RND<.67 THEN GOTO 2250
 540 POKE A,0
 550 POKE B,7
 560 GOSUB E
 570 POKE A,10
 580 GOSUB E
 590 PAUSE 100
 600 POKE A,0
 610 GOSUB E
 620 POKE A,9
 630 GOSUB E
 640 PAUSE 37
 650 POKE A,0
 660 GOSUB E
 670 POKE A,5
 680 GOSUB G
 690 FOR W=1 TO 12
 700 LET IN=USR F
 710 IF IN=4 THEN GOTO 760
 720 IF IN=1 THEN GOTO 760
 730 IF IN=5 THEN GOTO 760
 740 IF W=12 THEN GOTO 780
 750 NEXT W
 760 GOSUB D
 770 GOTO 380
 780 GOSUB D
 790 POKE A,10
 800 GOSUB G
 810 FOR W=1 TO 20
 820 IF W=20 THEN GOTO 840
 830 NEXT W
 840 GOSUB D
 850 POKE A,6
 860 GOSUB E
 870 PAUSE 90
 880 POKE A,0
 890 GOSUB E
 900 POKE A,5
 910 GOSUB G
 920 FOR W=1 TO 12
 930 LET IN=USR F
 940 IF IN=2 THEN GOTO 990
 950 IF IN=1 THEN GOTO 990
 960 IF IN=3 THEN GOTO 990
 970 IF W=12 THEN GOTO 1010
 980 NEXT W
 990 GOSUB D
1000 GOTO 250
1010 GOSUB D
1020 POKE A,10
1030 GOSUB G
1040 FOR W=1 TO 18
1050 IF W=18 THEN GOTO 1070
1060 NEXT W
1070 GOSUB D
1080 POKE A,9
1090 GOSUB E
1100 PAUSE 37
1110 POKE A,0
1120 POKE B,7
1130 GOSUB E
1140 POKE A,32
1150 POKE B,7
1160 GOSUB G
1170 PAUSE 60
1180 GOSUB D
1190 POKE A,16
1200 GOSUB E
1210 PAUSE 130
1220 GOSUB D
1230 POKE A,32
1240 GOSUB E
1250 PAUSE 45
1260 GOSUB D
1270 POKE A,144
1280 GOSUB E
1290 POKE A,16
1300 GOSUB G
1310 PAUSE 30
1320 POKE A,154
1330 GOSUB E
1340 PAUSE 20
1350 GOSUB D
1360 POKE A,128
1370 POKE B,7
1380 GOSUB E
1390 PAUSE 70
1400 GOSUB D
1410 FOR W=1 TO 300
1420 LET IN=USR F
1430 IF IN=128 THEN GOTO 1460
1440 IF W=300 THEN GOTO 1460
1450 NEXT W
1460 POKE A,64
1470 POKE B,7
1480 GOSUB E
1490 POKE A,96
1500 POKE B,6
1510 GOSUB E
1520 PAUSE 50
1530 POKE A,33
1540 GOSUB G
1550 PAUSE 10
1560 POKE A,97
1570 GOSUB E
1580 PAUSE 5
1590 GOSUB D
1600 POKE A,70
1610 POKE B,7
1620 GOSUB G
1630 PAUSE 220
1640 POKE A,64
1650 GOSUB E
1660 POKE A,69
1670 GOSUB G
1680 PAUSE 260
1690 POKE A,64
1700 GOSUB E
1710 POKE A,144
1720 POKE B,6
1730 GOSUB E
1740 POKE A,16
1750 GOSUB G
1760 PAUSE 10
1770 POKE A,146
1780 GOSUB E
1790 PAUSE 20
1800 GOSUB D
1810 LET IN=USR F
1820 IF IN=0 THEN GOTO 1840
1830 PAUSE 400
1840 POKE A,128
1850 POKE B,7
1860 GOSUB E
1870 POKE A,96
1880 POKE B,6
1890 GOSUB E
1900 PAUSE 100
1910 POKE A,33
1920 GOSUB G
1930 PAUSE 10
1940 POKE A,101
1950 GOSUB E
1960 GOSUB D
1970 POKE A,64
1980 POKE B,7
1990 GOSUB E
2000 PAUSE 40
2010 POKE A,6
2020 GOSUB G
2030 PAUSE 230
2040 GOSUB D
2050 GOTO 2210
2060 LET A=16522
2070 LET B=16524
2080 LET C=16521
2090 LET D=190
2100 LET E=200
2110 LET F=16514
2120 LET G=230
2130 POKE A,0
2140 POKE B,7
2150 LET OUT=USR C
2160 POKE A,0
2170 POKE B,6
2180 LET OUT=USR C
2190 PAUSE 400
2200 LET RN=1
2210 POKE A,5
2220 POKE B,7
2230 LET OUT=USR C
2240 LET TN=0
2250 LET TN=TN+1
2260 LET IN=USR F
2270 IF IN=1 THEN GOTO 30
2280 IF IN=2 THEN GOTO 250
2290 IF IN=4 THEN GOTO 380
2300 IF IN=3 THEN GOTO 250
2310 IF IN=5 THEN GOTO 380
2320 IF IN=7 THEN GOTO 30
2330 IF TN=20 THEN GOTO 530
2340 GOTO 2250
```

The easiest way to tell the two versions of the CC board apart is that the newer version has a 74LS27 IC chip located next to the optional LM323 voltage regulator while the older version does not. By the way, I highly recommend using the optional voltage regulator, because it lets you bypass the voltage regulator in the ZX81 and you can kiss overheating problems goodby forever.

If you have the older version you can plug the Zodex board directly onto an edge connector on the CC board. Although there are several ways to install the required decoder circuit, I recommend writing to Computer Continuum and asking for a copy of the documentation sheet for the new version. Figure 1, schematic, and Figure 2, legend, is all you will need. Then install the 74LS27 just as it is installed on the new version. It can be installed in the same spot as the new version with an IC socket, a few jumper wires, and some cuts in the circuit board foil. If you do this, you have essentially the newer version.

If you have the newer version of the Computer Continuum board, the decoder is already installed. If you do not want to solder the Zodex board(s) directly together, you will have to build an intermediate connector. One solution is shown in Photo 1. The pinouts of the .1 inch center edge connectors are jumpered to the correct fingers of the .156 inch center, 4 x 5 inch PC board.

Robot Expansion Plans

I hope I have helped you get started in a robot project. If you are serious about a self-contained robot, I recommend the Radio-Electronics robot reprint articles as a source of much useful information. The whole idea of this project to internally control a robot with a ZX81 computer is to demonstrate how much power the little computer really has. I have not yet maxed out the 16K RAM, although I am ready with a 16K Byte-Back module to add to the Sinclair 16K RAM pack.

Future robot expansion plans include measurement of robot movements and feedback of this information into the computer memory so that the robot can learn as it moves about and functions. A digital voice and voice recognition circuit is also possible since these circuits are becoming available in the $50-150 range. The ZX81 can be expanded to do an almost limitless number of functions without great cost.

And finally, even if you go with a full-blown robot project, you do not have to sacrifice your ZX81 or TS1000 to dedicated robot control. A keyboard plug and an extension of the video plug have been added to my ZX81 in the robot. The robot can stop and perform as a regular computer by simply plugging in an external keyboard and video display. ■

So You Wished You Had Bought A TS2000

Daniel G. Roy

The Challenge of the TS2000

How would you like to have a computer with a color video display of fifteen colors, quality sound, high resolution, unlimited character sets, and a dual joystick interface? How would you like a system in which you do not have to worry about expansion? If you have a ZX81 (or ZX80 with the 8K ROM), you could have such a system—the *COLORSIN81.*

Since ZX81 hardware and software are incompatible with the TS2000 expansion bus, many of us who have made sizeable investments in these items will not be able to justify purchasing the new product, as is the case with me.

This article sets forth my answer to the challenge of the TS2000 in a design to give the ZX81 the capability of having all of these features at a very reasonable cost. We will cover the system features, circuitry background, applications, construction of the board, testing and debugging, and programming. Many of the debugging suggestions are useful in other applications.

System Features

Most peripherals on the secondary market provide the user with a new capability or function. They normally are not designed or sold to be interactive with the user or the machine. This system has been designed differently; it has the user in mind. By building or purchasing this system, you are not only adding the features mentioned, but are actually opening your system to be anything that you want it to be.

Figure 1 compares the COLORSIN81 with the TS2000 in features, ease of use, and expandibility.

The two systems use entirely different approaches in creating their displays. The TS2000 uses a new ULA to produce color, with the high resolution being a product of new software. The COLORSIN81 uses a dedicated IC to produce and maintain a display. It requires none of the user memory! It has its own 16K of video memory to store images and pages in. As you will see later, this protected memory has many other uses.

The 6-slot motherboard includes two slots which will accept Radio Shack stocked boards. For interfacing your homebrew circuits to the Sinclair I have included 8 memory-mapped select lines. These are for the exclusive use of experimenters and hobbyists.

Daniel G. Roy, 99 Andover St., Lawrence, MA 01843.

So that the user does not have to "call" the capabilities of the board when required, the computer jumps to the system PROM, does the initialization of the system, loads the color display into memory, enables the sound, checks for joystick activity, and prompts the user with a "ready" on the screen.

Because the system PROM does the initialization, 64K RAM packs are fully supported. POKEing the Sinclair RAMTOP variables to have access to the upper half of memory is not necessary.

Since this system does not depend on the Sinclair to maintain a display, the computer may be run exclusively in the FAST mode. However, if you want both displays at the same time, you could run the system in the SLOW mode and use two TVs.

Figure 1. Comparison of COLORSIN81 and TS2000 Features.

	COLORSIN81	TS2000
Number of colors available	15 + transparent	8
Maximum pixel resolution	256 × 192	256 X 192
Sound range (octaves)	8	10
Sound produced by:	speaker	piezoelectric element
Number of joysticks	2 (4)	N/A
Characters/line	32-40	32
Ram available to user	56K	48K less display
Additional video ram	16K	N/A
Program merging supported	yes	no
Sprites available to user	32	N/A
User definable characters	256-768	21
Character sets redefinable	yes	no
Expansion slots provided	6	1 (the bus)
Interface circuitry provided	8 select lines	N/A

New Commands

The system adds 17 new commands (see Figure 2), including READ, DATA, and RESTORE. However, after you discover the power of the other commands, you will consider these to be less important.

You will now be able to MERGE and CHAIN programs, whether in Basic or machine language. Instead of writing

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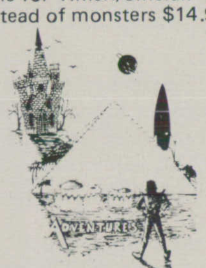

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All of the Adventures in this ad are in Basic. They are full featured, fully plotted adventures that will take a minimum of thirty hours (in several sittings) to play.

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TREK ADVENTURE by Bob Retelle — This one takes place aboard a familiar starship and is a must for trekkies. The problem is a familiar one — The ship is in a "decaying orbit" (the Captain never could learn to park!) and the engines are out (You would think that in all those years, they would have learned to build some that didn't die once a week). Your options are to start the engine, save the ship, get off the ship, or die. Good Luck.

Authors note to players — I wrote this one with a concordance in hand. It is very accurate — and a lot of fun. It was nice to wander around the ship instead of watching it on T.V.

DERELICT by Rodger Olsen and Bob Anderson — For Wealth and Glory, you have to ransack a thousand year old space ship. You'll have to learn to speak their language and operate the machinery they left behind. The hardest problem of all is to live through it.

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Authors note to players — This is a very entertaining and very tough adventure. I left clues everywhere but came up with some ingenous problems. This one has captivated people so much that I get calls daily from as far away as New Zealand and France from bleary eyed people who are stuck in the Pyramid and desperate for more clues.

MARS by Rodger Olsen — Your ship crashed on the Red Planet and you have to get home. You will have to explore a Martian city, repair your ship and deal with possibly hostile aliens to get home again.

Authors note to players — This is highly recommended as a first adventure. It is in no way simple—playing time normally runs from 30 to 50 hours — but it is constructed in a more "open" manner to let you try out adventuring and get used to the game before you hit the really tough problems.

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each program from the first line each time, just load in any number of subroutines and combine them with your new "application." Your programming speed will increase many times over. By "chaining," I mean that a tone could place in protected memory certain items of data and have this data shared by many other programs, each being able to change or modify the contents of the data.

Files and other data structures are supported on this system with easier manipulation of information. You will not have to dimension arrays for storing data, worry about RUN or CLEAR destroying hours or days worth of work, or be concerned with managing the memory.

You will be able to create animation easily, plot complex functions directly in high resolution, if desired, and easily interface your machine language programs with a special COLORSIN81 system variable which contains the starting address of your routine. This routine may be located anywhere in user memory in either a REM statement or a string. The system software keeps track of its location and automatically adjusts the variable.

If you should like to obtain additional reading material on other similar applications and sources of supply for kits and assembled systems, see the lists at the end of the article.

System Overview

The system consists of a buffered motherboard with six expansion slots. Two of these slots are designed to accept Radio Shack boards.

Color with a VDP

Color is produced using the TMS9918A Video Display Processor from Texas Instruments, hereafter referred to as the VDP. The VDP has the capacity for producing color displays and high resolution as well as the ability to create and manage 32 additional characters called sprites. A sprite is a variable sized character which may be moved smoothly over the entire display area in any direction. Each of the 32 sprites has its screen position determined by its own screen address, so creating animated sequences merely becomes a series of timed changes to these screen locations.

The VDP also offers four different Modes, each with varying utility depending on the application. Modes I and II are graphics modes. Mode I offers up to 15 colors plus transparent to be displayed on the screen at once. Up to 256 unique characters may be defined. In addition to allowing the 15 colors plus transparent to be displayed at the same time, Mode II allows all 16 colors to be present in the same character position. Mode I allows any combination of 8 colors maximum to be displayed in any one character position. Mode II offers up to 768 unique characters per display.

Because of the unlimited and unrestricted use of color in Mode II, this system utilizes it as the high resolution, 16- color mode. Mode I, because of its limitation on colors, is used as a high resolution, 4-color mode.

Mode 1 is sufficient for most appliciations, and allows the user the advantage of storing up to four pages in memory at a time, making paging very simple and quick. Mode II displays

Figure 2. The 17 New Commands.

1. REM*DATA;A$;X1,x2...Xn:

A$ is the "name" assigned to a particular set of data. An unlimited number of data elements may follow, each separated by a semicolon and the last element followed by a colon.

2. REM*READ A$;X

Reads an element from the data named A$.

3. REM*RESTORE A$

Resets the pointers to begin at the first data element in A$.

4. REM*OPEN N

N is a file name previously defined using the FILENAME command and limited to an alphanumeric of fewer than 3 characters.

5. REM*CLOSE N

Closes the file and "protects" it from accidental access during the run of a program.

6. REM*CIRCLE;X;Y;Radius;Color:

A subroutine to draw a high resolution circle anywhere on the screen with any radius. Any of the 15 available colors may be used.

7. REM*FILL

Fills the bounded area of the CIRCLE or DRAWTO command with the same color as indicated.

8. REM*FILENAME X$;

Any three character alphanumeric to "name" a file. As such, its location can be stored and recalled by name. It may also be a copied page of the display.

9. REM*VARS A$;

Allows the user to name a variable being used by the Basic operating system to be used also by COLORSIN81 system commands such as DATA, FILENAME, FIELD, and SOUNDON. This variable may then be manipulated by a Sinclair Basic program and instantaneous values used by the system.

10. REM*FIELD:FILENAME:1 as 2$;2 as 4$;3 as 1$:...X as Y$:

By using the field command, you can assign specific memory requirements for each field. In the above example, the first field uses 2 bytes, the second uses 4 bytes, etc. The record length is associated to the FILENAME by the system software.

11. REM*MEMREM

When used in a GOTO statement, may be used to determine the total number of records which may fit in memory in any particular file. Uses the information provided by the FIELD command to make this calculation. The value returned may be POKEd to place additional files in memory.

12. REM*SOUNDON;channel,pitch,volume;etc.:

The main method of producing the sounds: the available channels are 1-4, the pitch may vary from 0-1023, and the volume from 0-15, with the value 15 shutting the tone generator off. May be used in conjunction with Basic variables which are manipulated by a program.

13. REM*HRPOS X

When used with a GOTO statement, then the current X,Y coordinates of character X are returned. Allows the programmer to determine in software the current location of any character on the screen.

14. REM*MEMLOC

When run as a GOTO statement, gives an approximation of the amount of available user Basic RAM space remaining.

15. REM*DRAWTO;X,Y;X,Y;.....X,Y;color:

Connects any two pixel coordinates on the screen. May be extended by as many destination points as desired without the final coordinates having to be the same as the first coordinate. Any of the available 15 colors may be used.

16. REM*BIN

When used in a GOTO statement, calls a special screen which may be used to define new characters, sprites, or a high resolution screen.

17. REM*MOVE;FILENAME; origin, destination:

Allows the programmer to move large amounts of information around in memory, to or from the protected memory of the video RAM. Implements the ability to "chain" and "merge" programs.

occupy 12K of video memory, so only one display may be stored in memory at one time. This mode seems best suited to games, creating highly detailed images to be dumped to the printer, and in creating displays where colors may be used either to form bounderies or to show movement. An example of this would be in CAD/CAM, where an electronic circuit could be displayed on the screen, and the pulses on the circuit shown as changing colors on the line.

Mode III on the COLORSIN81 may best be described as the multicolor, block mode. All 16 colors may be displayed on a page, but a combination of four colors maximum may appear on any one character line. Because of this apparent problem, the system software will actively support four colors in this mode. Since the block graphics are very similar to those of the Sinclair, I have dubbed this the Sinclair mode.

In Modes I, II, and III, sprites and graphics are supported. Each mode has 32 character positions across and 24 lines down, the same as the Sinclair. The multicolor mode, Mode III, has 64 blocks by 48 blocks on the screen, again the same as the Sinclair. However, Mode IV offers 40 characters per line with 24 lines down. This mode increases the Sinclair screen by 25% and makes word processing and other text related tasks far more readable. Formatting becomes much easier if you are using an 80-column printer, for you should not have the problem of broken words. However, with this feature, you lose the use of sprites, and you are limited to two colors over the entire screen. However, I am sure that most of you will enjoy having a larger screen to work with.

In the foregoing discussion of the modes of the VDP, I mentioned that the system software supported what appeared to be less than the potential of the VDP. This is because it seemed sensible to make trade-offs if similar results could be obtained using one of the other modes. This makes software implementation much simpler and allows the use of the new commands (in Figure 2) to make programming much simpler.

However, since all of the functions on this board are memory-mapped, your are free to use Basic or machine language routines to create anything you wish. Figure 3 compares the four modes and gives a synopsis of their capabilities.

The COLORSIN81 offers a number of special screens which may be called as required. These screens will help in defining your new character set, defining new sprites, or helping construct a high resolution screen in Mode II. These screens are interactive in that the user is asked to supply very simple information and the computer/software takes care of storing that information in the appropriate memory locations. All screens and files in this system may be saved on tape, so any

Figure 3. Comparison of the Modes.

	Mode 1	2	3	4
Characters/line	32	32	32	40
Lines/screen	24	24	24	24
Number of sprites	32	32	32	0
Graphics supported	yes	yes	yes	yes
Characters supported	yes	yes	yes	yes
Resolution	high	high	block	high
Number colors/screen (maximum)	16	16	16	2
Number colors/screen supported	4	16	4	2
Maximum number of user defined Characters per screen	256	768	256	256

work which you might want to include in another program may simply be merged with it.

The Sound Chip

Sound is produced with the SN76489A Sound Chip from Texas Instruments. This IC offers an 8-octave range and 4 separately programmable channels, the fourth being a white noise generator. Full tone and volume control are accessible. Programs may be written in either Basic or machine language. Envelope control allows you to produce complex tones that simulate the piano or chimes.

The calculated frequency range in this system is approximately 100-10000 Hz, which should be sufficient for most applications. The sound is output through an 8 Ohm speaker, so the sound quality is very good.

The application sheets available from Texas Instruments create a fairly complex maze of registers and formats which must be considered when outputting a specific sound. However, the COLORSIN81 software takes care of formatting the information when the user loads simple, direct items of information into a command line.

The sound capability has applications in games, in word processing programs for positive key feedback , and in security systems as an audible noise source.

The Joystick Interfaces

Two joystick interfaces are provided on board, but up to four may be active at any one time. These interfaces accept inexpensve Radio Shack joysticks. The 6-bit resolution is sufficient to uniquely identify every character position of the screen. If the joystick is used to manipulate the position of a sprite, then the sprite may be positioned to the accuracy of a half character.

This feature is designed for applications in alternative input mechanisms, in gaming, and in aiding the manipulation of screen data. When used with the appropriate software, it could be used to change screen information, to move characters or words from one location to another, or to highlight an area on the screen.

Additional Options

At the time of this writing, several other options were being considered for the board: 1) up to 48K RAM on board, in increments of 16K; 2) a solid state interface to allow the user to "plug in" programmed PROMs apart from the Sinclair memory space and load into memory when needed (up to 80K of PROMs could be supported on the system, while using only 8 memory locations of the Sinclair memory); 3) an interface which would emulate a disk drive. The principle is the same as the solid state interface, but would use dynamic RAMs instead. These new products will become available over the next several months.

Schematic Overview and Circuit Operation

The motherboard consists of Slot 0, where the Sinclair bus originates. The address, data, and selected control lines are buffered by ICs 1-4. The PROMs, P1 and P2, provide all the address decoding required on the board.

The outputs of the PROM are used to enable ICs 8 and 33, which are one-of-eight decoders. Inputs A, B, and C provide binary information which is coded by IC 8 to produce one of eight active low outputs at one time. On IC 8, input A is grounded because address line 0 is used as a mode control for the VDP. The eight outputs (select lines) on IC 33 are extended to the Radio Shack boards to give the user total access for interfacing other homebrew boards.

IC 9, sections of which have WR inputs and RD inputs in addition to the inputs from IC 8, provides the necessary signals to the sound and joystick sections on the board.

The PROMs allow flexibility in design, in that the relative addresses of the peripherals on the board could be easily changed by changing the programming of the PROM. However, to maintain compatibility with other systems, the PROM programming should not be changed.

ICs 10 and 11 are latches used to store and continuously ouput their contents. In the joystick section, the output of the latch is fed into a CD4050 CMOS buffer. This chip is used because of its ability to output stable and reproducible voltage levels on its output. The output of the chip is fed into a resistor bridge, effectively assigning a "weight" to each of the data bits.

The sum of these weighted voltages is then fed to the negative side of IC 22, a voltage comparator. The function of the comparator is to output a positive voltage if the positive side of the comparator is greater than the negative side, and to output a negative voltage when less than the negative side. The voltage source for the positive side comes from the joystick itself. The joystick has its own 5 volt supply which may be varied by the dual potentiometers from 0 to 5.0 volts. The effective range, after going through a matching circuit of resistors, is approximately 0.25-4.75 volts. Because we are feeding 6 bits of data into the section, this 4.5 volts is divided by 64 equal units of approximately 0.07 volts.

Thus, any change in the position of the joystick creating greater than a 0.07 volt change could change the position of the cursor on the screen. However, in practical terms, we are concerned with character positions on the screen, so the full precision of the joystick will not be used. However, the software compensates for this when using sprites as the cursor by developing trend data in direction and speed to produce smooth movement instead of the expected jerky movement.

The function of IC 23, a buffer, is to make visible to the Sinclair via the data bus the present condition of the comparator. The processor, when in the joystick routine, continuously outputs data to the joystick latch and then reads the joystick port to sense any change in the outputs of the comparator. A change indicates that either the X or Y screen coordinate of the cursor has been determined.

In the sound section, the output of the latch is fed to the 76489A sound chip as data. The sound chip requires that the data be stable for a minimum of 32 clock cycles at 2 MHz. Because 2 bytes of data are required to produce a tone, a maximum of 3200 different tones may be produced per second using machine language programs.

In Basic, you are not really restricted by the 32 clock cycle requirement, for it takes a minimum of 1 ms. to execute a Basic instruction. Therefore, a maximum of 500 tones per second could be produced. Various frequencies are produced by rapidly turning the tone generators on and off with a seed tone varied by time.

The function of ICs 28 and 30 is to divide the 4 MHz frequency in half to 2 MHz, the maximum frequency the sound chip can handle. The audio output of the sound chip is fed to IC 32, an audio amplifier which is used to amplify the tone and drive an 8 ohm speaker. The large capacitors are used to improve the bass response of the speaker.

The video section does not use latched data, but receives its data directly from the data bus. Since the VDP operates asynchronously, data may be read or written to the VDP without considering what the VDP may be doing at that moment. The VDP has its own internal latches to store data until it is able to act upon it. Because of its high clock rate, there is no degradation in system throughout. You may run machine language programs at full speed reading or writing data without the VDP losing any of it.

The VDP interfaces to the CPU by the data bus, two select lines, a Mode Control line which is address 0 on the Z80 bus, and the reset line from the Z80. On power up, the reset line resets all registers in the VDP and clears all memory. It is now in a position to be programmed with data.

Programming is accomplished through the use of the select lines, the Mode Control line, and the data bus. The Mode Control line differentiates between VDP register accesses and video RAM accesses. The CSR and CSW lines, active low, determine whether the CPU is reading or writing to the VDP. These signals are used to strobe data into the VDP. The VDP then performs the required housekeeping duty of putting the data in the appropriate register or video memory location.

The VDP also refreshes the dynamic RAMs. The video RAM side of the VDP uses multiplexed address/data lines to determine a video RAM address. Two bytes of data are needed to set the starting address, and one byte of data for each data word to be read or stored.

The VDP features an autoincrementing register, so that, once the initial address has been set up, succeeding data transfers do not need new addresses. At this point, the VDP is processing the data stream as a parallel port. The 10.73 MHz crystal may be fine tuned by using the trim capacitor. It is used to adjust the crystal frequency to match the pixel rate of your TV. The composite video out signal is fed to an RF modulator which conditions the signal so that channel 3 or 4 may be used to display the images on your TV. However, if you wish to drive a color or monochrome monitor, a jack can be provided.

Constructing and Debugging the Board

This system was designed for incremental construction. Although the basic price of the system is low, some may prefer to spread the cost of the system over a period of time. Certain basic sections of the board must be present for others to operate, but, once these sections are built, you can extend the system at your own pace.

The system interfaces to the computer in one of two ways: 1) by a cable running from the expansion port of the cased computer to slot 0 of the COLORSIN81; or 2) by plugging the uncased computer directly into slot 0 on the motherboard.

If you have an auxilliary keyboard, you can connect it to the motherboard using the 25 pin D-type connector on the board; however, you can do this only if the computer is plugged into slot 0, for that is the only way to connect the flex-tail connector of the board to the keyboard input connectors on the computer. You should decide before ordering what approach you would use to interface the computer to the system.

Actual construction time of this board will vary from 3-5 hours for the experienced kit builder to 10-20 hours for the novice kit builder. If you built your own computer, then you should have no problems. However, even the novice kit builder, taking his time and following the suggestions in this article and in the assembly instructions, should be able to build this system.

Before beginning construction, assemble the basic tools: a 25-40 watt pencil type soldering iron, solderwick, screwdrivers, a multimeter, and a set of tweezers. The kit building progresses one section at a time, so you should segregate all the componements in the kit, arrange them by section, and bag each section. This will ensure that all the parts you need are present and will eliminate much searching when you actually are building the kit.

In general, the basic sequence of inserting parts onto the board should be: IC sockets, capacitors, resistors, diodes, followed by other discretes such as potentiometers, variable capacitors, and transistors. This approach allows you to use your best judgment in the placement of the components.

The Power Supply

I recommend a 15 volt, 5 amp power supply to accommodate future expansion of this system. When fully built with the computer and a 64K RAM pack attached, the power consumption approches 2.0 amps at 5 volts. If you intend to add more than 2-3 boards to the system, you might need to add a second 5 volt regulator. Although only +5 and +9 volts are required in this design, the board has room to accommodate +12 volts and -5 volts, obtained using an inexpensive voltage converter.

By purchasing the proper type of power supply, you will eliminate much frustration in the future. The power supply should have a regulated output. (When ordering a kit or assembled system, inquire about the availability of a power supply if you need it.)

The Power Regulating Section

The first part of the board to be built is the power regulating section. This is made up of 3 regulators and heatsinks, 1 IC, and several resistors, capacitors, and diodes. If you put the components into groups, assembly will proceed much faster. Starting with one of the voltage regulators and its associated parts, assemble the parts to the board and solder using the component placement layout in Figure 4.

Figure 5 is a schematic of the system and should be used when debugging the board. You might want to test the power supply before connecting it to the board. Turn power on to the supply with no connections to the motherboard. You should have a voltage of 15-18 volts. After all the components for the power section have been soldered, attach the power supply and turn on the power. Referring to Figure 4, locate appropriate test points and adjust the appropriate variable potentiometer until the desired voltage is obtained. When inserting components into the board, pay particular attention to polarity of the capacitors and diodes. Improper placement will result in poor performance. Once voltages are set to the indicated levels, proceed to building the motherboard and buffers.

The Motherboard

Assemble all the parts for the motherboard and buffer section. Insert the IC sockets, followed by the connectors and other components. Carefully inspect your work for solder bridging, especially on the connectors. For thoroughness, you might want to check for continuity from one connector to the next; remember that the address, data, and certain control lines go through the buffers.

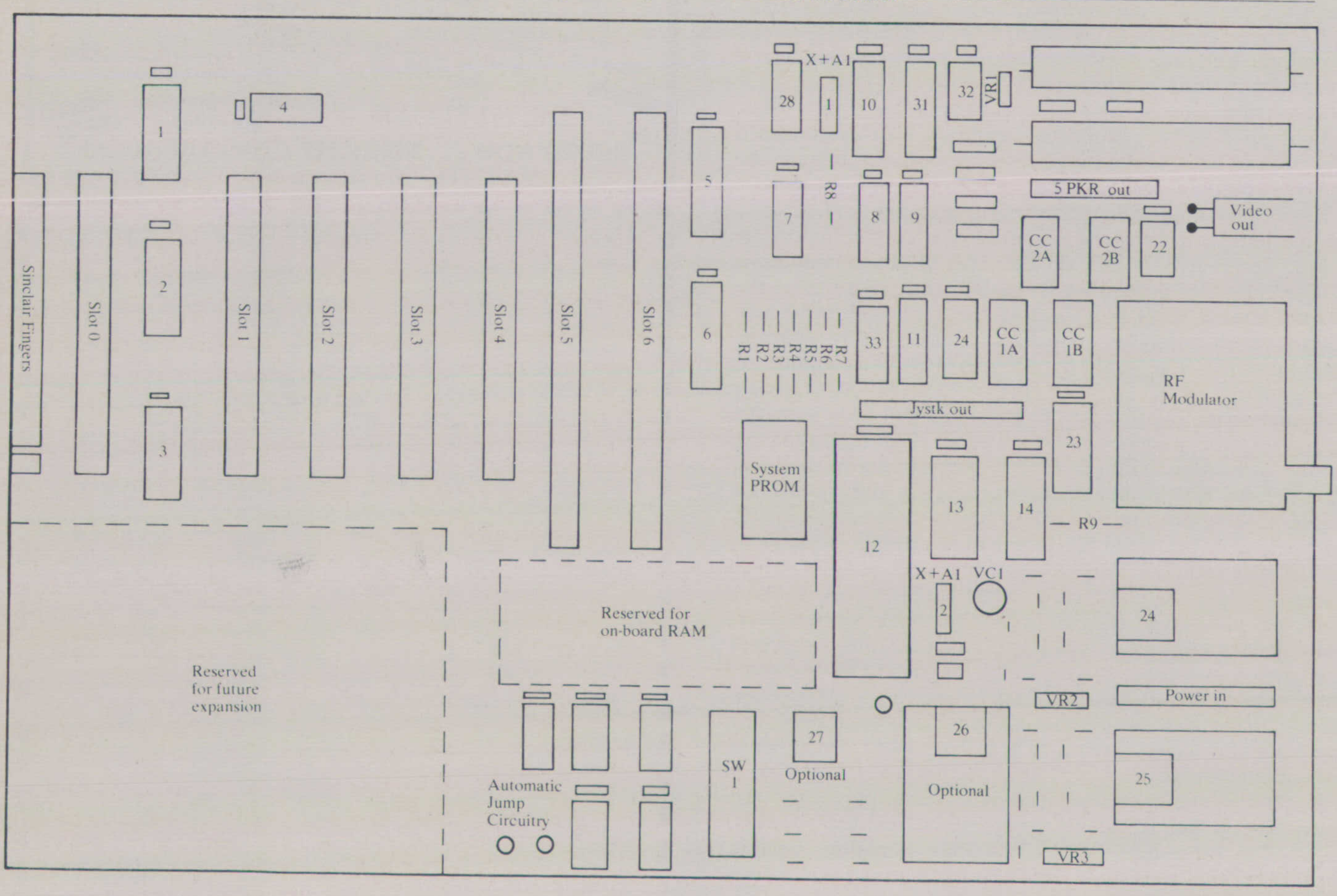
At this point, you have a fully functional motherboard and may begin using the power of the Sinclair to help in making the rest of the system operational.

To prove that your computer may help, attach it to the system, insert some known working board, other than a memory board, into one of the other slots and turn on the computer. If the board operates normally, then all aspects of the motherboard are operating as expected. If the computer works but the peripheral board does not, then the problem lies in the soldering of the connectors or IC sockets. If the computer does not produce a display, then the buffers are not operating correctly, and again soldering should be checked.

The Address Decode Section

This section is made up of 5 ICs and sockets, assorted capacitors and resistors. Insert the parts indicated, power the system up, and check for proper voltages by referring to

Figure 4. Component Layout of COLORSIN81 Board.



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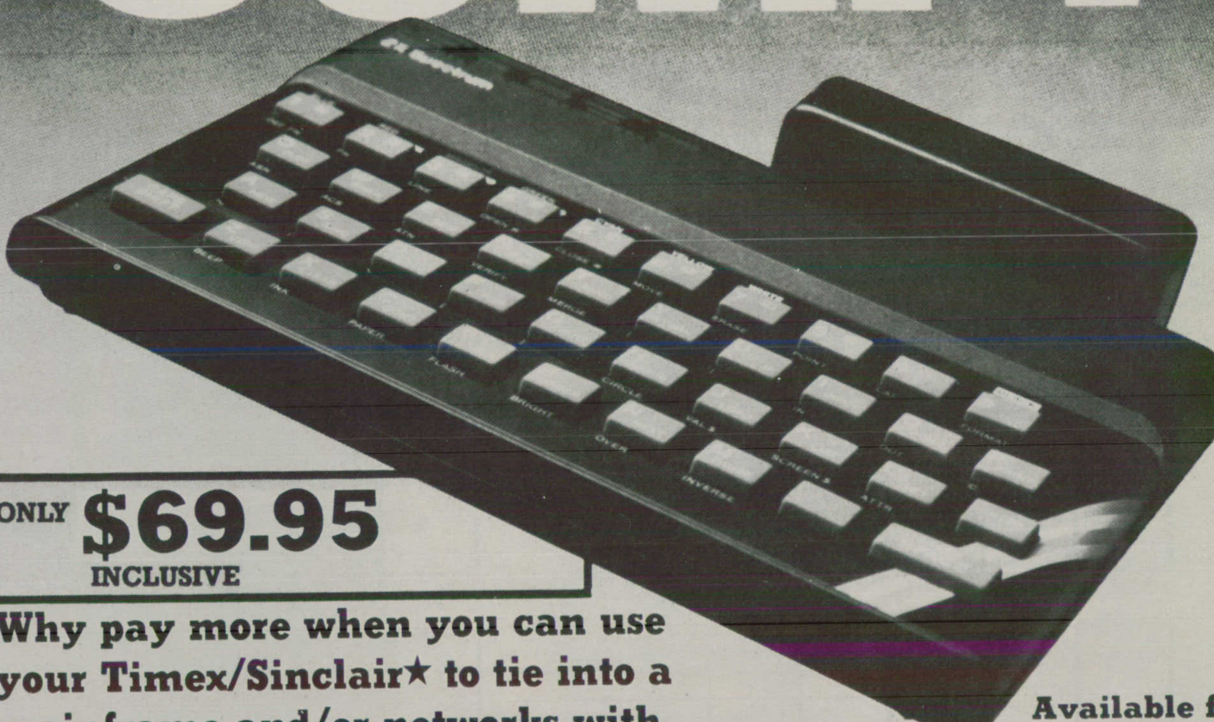

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Figure 6. If you have access to an oscilloscope, you can test this section by POKEing the select addresses as indicated on the schematic. If not, then you will have to wait until the next section is added to prove that the address decode section is operational.

The Joystick Interface

This section is made up of 4 ICs and sockets, capacitors, component carriers for the resistors and a large assortment of resistors. Begin by assembling the component carriers as in Figure 7. Now that 90% of the parts are assembled, you can concentrate on the sockets and remaining components. Insert the ICs, power the system up, and check voltages to the ICs.

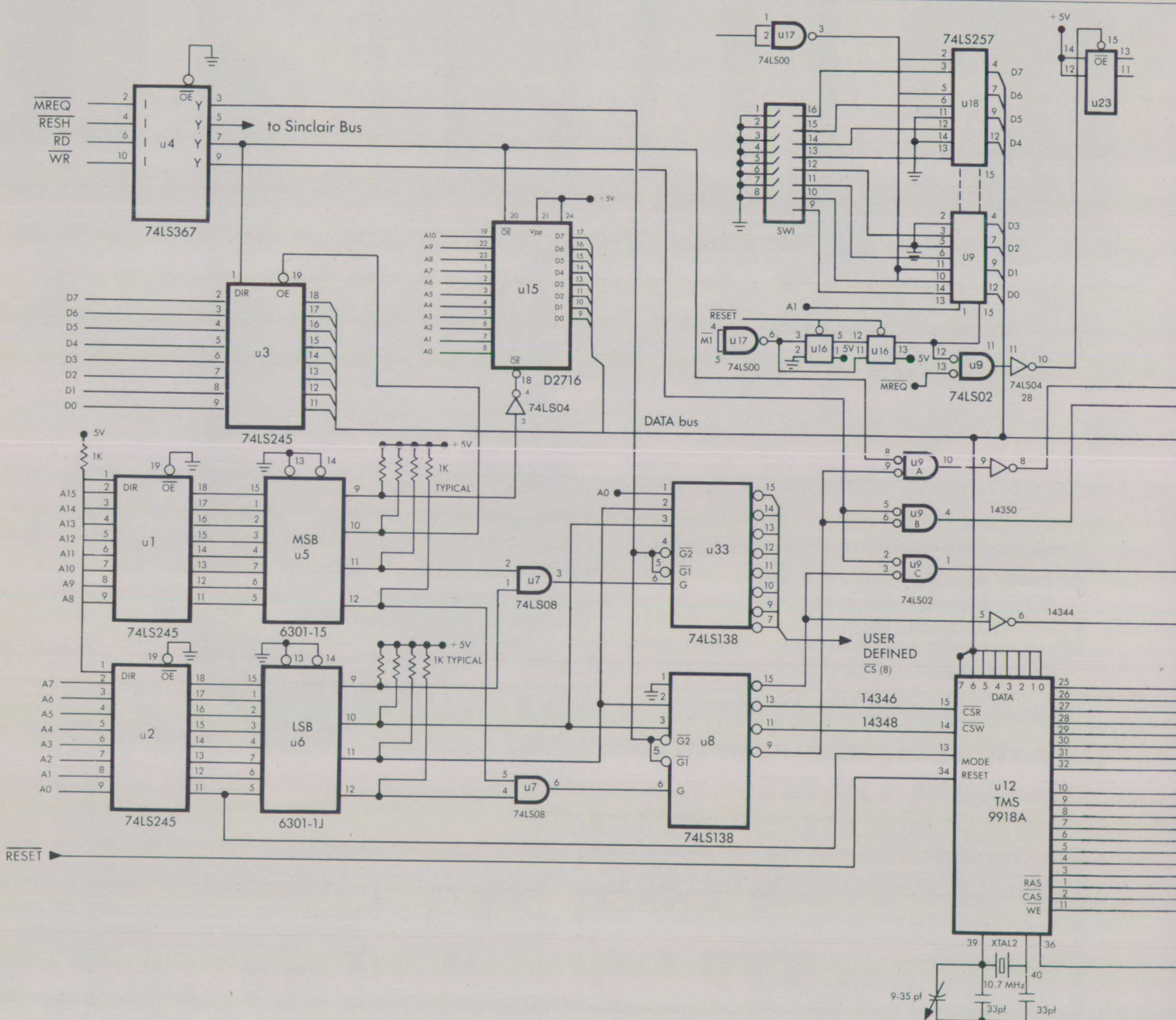
Once done, enter Listing 1 and RUN it. Check the output pins on IC1. You should see a rhythmic change in the measured voltage. If you do not see this activity, then check your soldering on both the address decode and joystick sections. If you still are unable to detect the indicated response to the program, then make a thorough check with a continuity tester. Check each line in the two sections to verify that no shorts exist.

Finally, if no problems are detected, then try one of two other approaches: 1) contact a friend who has a logic probe or an oscilloscope and ask for assistance in finding the problem; or 2) purchase additional parts from a supplier such as Radio Shack to isolate the problem. Although no one ever likes to admit it, occasionally component failure is the cause when a project does not work.

After you are able to observe the desired response to the program, insert ICs 22-24 and the component carriers as in Figure 4. Power the system and enter Listing 2. If you have purchased a Radio Shack joystick, assemble it as in Figure 8. Connect the joystick and RUN the program.

You should be able to place the cursor in each of the four corners of the display. Do not be alarmed at the response of the joystick. The machine language program will run many

Figure 5. Schematic for COLORSIN81.

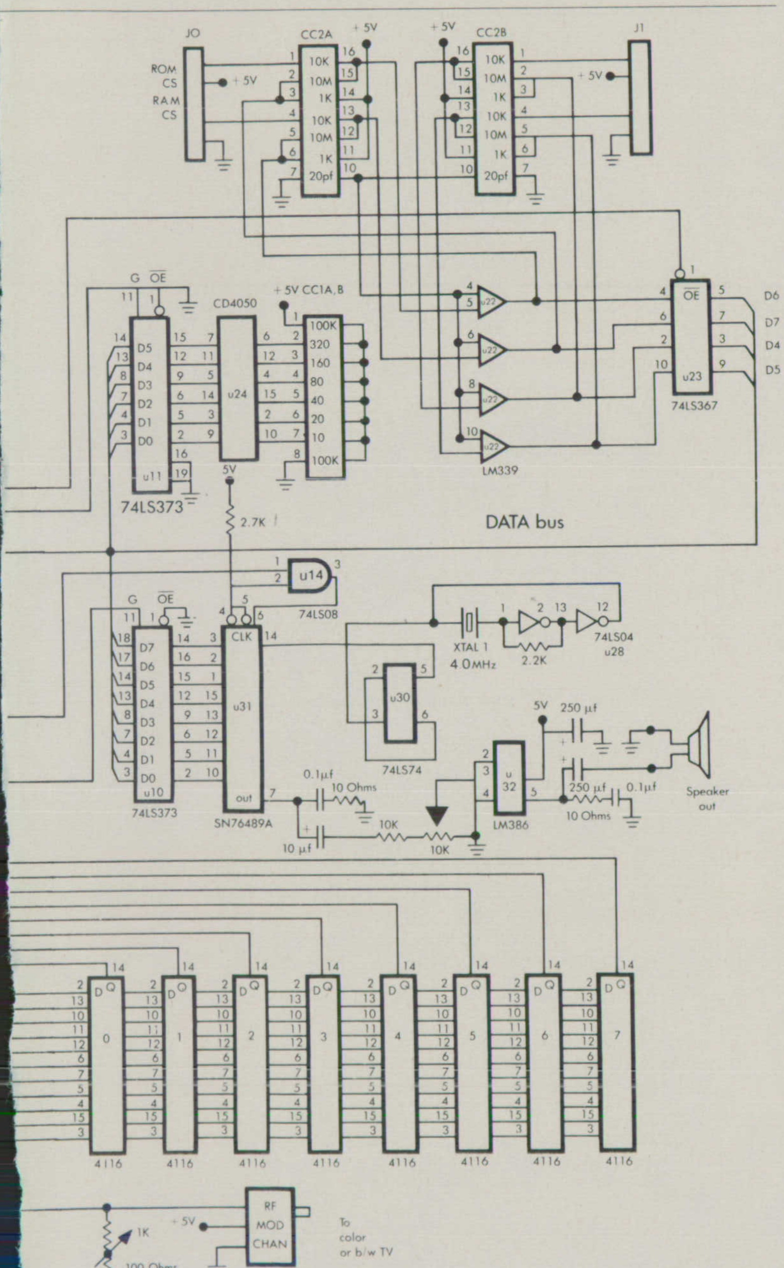


times faster than this Basic program. As the cursor position is changed from corner to corner, you might take a voltage reading at pins 1 and 2 of the voltage comparator, IC 22. You will see the maximum voltages that may be outputted to the two sides of the comparator.

Sound Section

Assemble the parts for this section and solder. You should have 4 ICs and sockets, a crystal, resistors, a variable resistor, 2 large capacitors, and a number of small capacitors. Do not insert IC 32 yet, as you do not want to output a load without a speaker attached. However, if you want to connect the speaker at this time, you can leave it in.

Enter Listing 1 again, changing line 40 to POKE 14344. Run the program to again observe the rhythmic changing of the voltage levels, particularly on pin 2 of IC 10. Do not be concerned with the hiss that you might hear from the speaker. The sound chip occasionally outputs a sound on power up.



You can reduce the volume by adjusting the variable resistor.

Enter the program in Listing 3 and RUN it. You should hear a series of tones which sound like a chime. Adjust the variable resistor until succeeding runs of the program produce the tone at the desired volume level. Now proceed to the next section.

Figure 6. Power Connections.

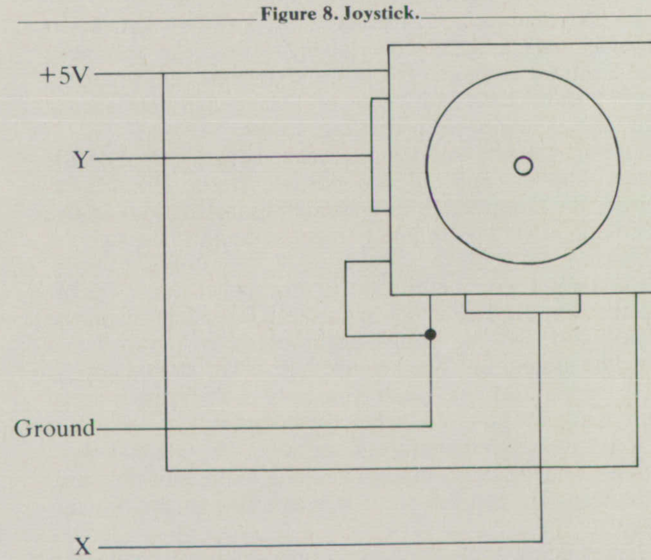
IC	P/N	GRD	+5	+9
1,2,3	74LS245	10	20	
4,23	74LS367	8	16	
5,6	6300-1J	8	16	
7	74LS08	7	14	
8,33	74LS138	8	16	
9	74LS02	7	14	
10,11	74LS373	10	20	
12	TMS9918A	12	33	
14	74LS08	14	7	
15	D 2716	12	24	
16, 30	74LS74	7	14	
17	74LS00	7	14	
18,19	74LS257	8	16	
22	LM339	12		3
24	CD4050	8	1	
28	74LS04	7	14	
31	76489A	8	16	
32	LM386	4	6	+12 -5
34,41	4116-150	16	9	8 1

Figure 7.

1	261 K	100 K	10 K
2	147 K	51 K	10 MEG
3	75 K	5 K	1 K
4	38 K	13 K	10 K
5	19 K	5 K	10 MEG
6	10 K	2.6 K	1 K
7	100 K	1 K	20 pf
	CC1A	CC1B	CC2A,B

Insert the resistors and capacitors into the component carriers as shown. Resistors in CC1A, B are 1% resistors. CC2A, B have 5% resistors.

Figure 8. Joystick.



Assemble the Radio Shack joystick as shown. You should get a dual 100K joystick.

Listing 1. Latch test.

```
10 SLOW
20 LET Z=14350
30 FOR I=1 TO 128
40 POKE Z,I
50 NEXT I
```

Video and Video RAM

This is undoubtedly the section many of you have been waiting to get to.

This section consists of 3 ICs and sockets, an RF Modulator and/or a monitor jack, a variable capacitor, a crystal, and several resistors and capacitors. Insert and solder all the components as in Figure 4.

Enter the program in Listing 4 and RUN. This program loads data into memory locations in video RAM and then reads these same locations and prints the results. You will notice that the program increments the data in multiples of 2; if, when printing the information to the screen, you notice a zero appearing where a number should be, this can aid you in determining that you might have a bad solder point in the section. It will even help to identify which line might be bad in that each bit of data has its own pin on the RAM chips that it enters and exits. If the demonstration program does not operate as expected, again check soldering quality and continuity. When the section works, you are ready to add the PROM interface and the automatic jump circuitry.

This section will be revised later to make use of the new 4416 memory chips from Texas Instruments when they become available. The required chips will be reduced from eight to two. This offers many advantages to the kit builder and user because debugging is much simpler and system reliability is increased. These chips could also be used whenever the on-board memory option is added and whenever possible in other suitable applications.

Figure 9. Switch Settings.

	1	2	3	4	5	6	7	8	
A	0	0	0	0	1	1	0	0	1 = On 1 = Off
B	0	0	0	0	0	0	0	0	

Set the switch as in A to cause an automatic jump to the system PROM. Use the settings in B when running unmodified Sinclair programs.

PROM Interface and Automatic Jump Circuitry

The PROM interface consists of 1 IC and socket. Insert and solder and check for proper voltage levels. The Automatic Jump circuitry consists of 4 ICs and sockets, an 8-position switch, 2 transistors, and 2 resistors. Insert the components, solder and check for proper voltage levels.

You might notice that you no longer have a cursor on the display. This is expected and normal. If the PROM was inserted, the computer is now executing instructions in this PROM and is waiting for you to input something through the keyboard.

At this point, you might want to disconnect the TV cable from the Sinclair and attach it to the RF modulator on the motherboard. Set the switch positions as in Figure 9 and power the system up. The prompt "READY" should appear on the screen. At this point you have a fully operational system ready for you to develop applications.

If you have a video monitor, or another TV, you may want to connect one to the computer and one to the motherboard. In this way you can see what is happening to the Sinclair display.

When running application programs which have not been converted to run on this system, set the switch positions as in Figure 8, power the system up, and observe the results of the

Listing 2. Cursor test.

```
5 LET X=0
7 LET Y=0
10 SLOW
20 LET Z=14350
30 FOR I=1 TO 127
40 POKE Z,I
50 IF PEEK Z=128 THEN GOTO 150
60 IF PEEK Z=192 THEN GOTO 200
70 NEXT I
80 FOR I=1 TO 64
90 POKE Z,I
100 IF PEEK Z=64 THEN GOTO 170
110 NEXT I
150 LET X=I
160 GOTO 80
170 LET Y=I
180 PRINT AT X/8,Y/4;CHR$128
190 PRINT X
195 PRINT Y
200 STOP
210 LET Y=X
220 GOTO 180
```

Listing 3. Chime demonstration.

```
10 FAST
20 LET Z=14344
25 REM TURN OUTPUTS OFF
30 POKE Z, 159
40 POKE Z, 191
50 POKE Z, 223
60 POKE Z, 255
65 REM INPUT ANYTHING
70 INPUT A$
75 REM ENABLE THE OUTPUTS
80 POKE Z, 140
90 POKE Z, 5
100 POKE Z, 170
110 POKE Z, 5
120 REM NUMBER OF BELLS
130 FOR B=0 TO 11
140 FOR I=145 TO 159
150 POKE Z,I
160 POKE Z,(I+32)
170 REM DELAY
180 FOR D=0 TO 1
190 NEXT D
200 NEXT I
210 NEXT B
220 GOTO 10
```

Listing 4. VDP and memory verification.

```
5 LET Z=0
10 FAST
20 LET WR=14349
30 LET RWR=14348
40 LET RRD=14346
50 REM SET UP STARTING ADDRESS
60 POKE WR,0
70 POKE WR,64
80 REM ENTER DATA
90 LET Z=Z+1
100 FOR I=1 TO 50
110 LET Z=Z*2
120 POKE RWR,Z
130 NEXT I
140 REM READ DATA
150 POKE WR,0
160 POKE WR,0
170 LET Z=1
175 SLOW
180 FOR I=1 TO 50
190 LET Z=Z*2
200 PRINT PEEK (RRD);
210 PRINT CHR$0;
220 NEXT Z
230 PRINT "DONE"
```

Try varying the numbers in lines 140 and 180. Observe the effects.

Lost Continent

program through the Sinclair TV display port. If the sound or joystick features are to be used, then at some point early in the program LET Z = USR x, where x represents the beginning of the PROM subroutines for these features.

Programming the System

The joysticks are enabled in this system by POKEing six memory locations. The first location tells the software how many joysticks are to be active during this time period, and the second location actually enables the joysticks. Up to four joysticks are supported by the software. The next four locations are used to store the code number of the character to be used as the cursor for each joystick. If you wish to use sprites to indicate the position of the cursor, then zeros should be POKEd into these locations. The software will automatically use the four highest priority sprites as cursors.

The sound features are implemented by the SOUNDON command. The three parameters in the command are used to choose the desired tone generator, the pitch to determine the frequency, and the volume which is used not only to vary the volume, but also to turn a tone generator off. You can use variables for any of these parameters so long as they have been declared previously by the command VARS. You may also add multiples of these three parameters in the same REM line if you wish, the only condition being that separate groups be separated by semicolons and that a colon follow the last parameter in the REM line.

Most of the other commands are self-explanatory, and a bit of experimenting will quickly enable the programmer to produce application programs far easier than ever before and in much less time.

For those who purchase a kit or an assembled system, the accompanying manuals will detail in far greater depth how to program the system and develop applications. Sample programs and applications will be included to help encourage the new owner to discover the true power of this system as compared to the unmodified Sinclair.

Conclusion

I am sure that many of you are looking forward to using your *new* Sinclair. You should! You now have one of the most powerful computers on the market for under $1000. You have the superior graphic capability of the Texas Instruments 99/A computer, the high resolution of the Apple, the easy editing of the TRS-80, and sound comparable to the best on the market. You have the advantages of easy expandibility and interfacing, of adding new utilities on PROM to further expand the capabilities of the system, of adding new RAM to the system inexpensively, and of connecting your keyboard, if you have one, to the system. Best of all, you have the advantage of being able to expand your system at will from the large selection of inexpensive Sinclair peripheral equipment on the market.

I am sure that many of you are indecisive about investing in this type of expansion because a "better" computer might become available, or because this is your first computer and later you might decide to get another. Well, this system is portable. It may technically connect directly to *any* Z80 based computer such as the TRS-80. You might not be able to use the PROM designed to work with the Sinclair, but adding several routines to accommodate the TRS-80 should not be at all that difficult. Also, since most of the Z80 signals are duplicated in some manner on other microcomputers on the market, interfacing should be relatively simple. So not only are you investing in your Sinclair for today, but also you are looking forward to extending the capabilities of your future system.

References

I wish to acknowledge my indebtedness to the following authors and publishers for their kind permission to use concepts from their work in developing this project:

"Add Programmable Sound Effects to Your Computer," by Steve Ciarcia, *Byte,* July 1982, McGraw-Hill Publishers.

"Build a Joystick A-to-D Converter for Your TRS-80 Model I/III," by William Barden, *Byte,* January 1982, McGraw-Hill Publishers. Used by courtesy of Howard W. Sams & Co., Inc.

"High Resolution Sprite-Oriented Color Graphics," by Steve Ciarcia, *Byte,* August 1982, McGraw-Hill Publications.

"A Guide to Using the Texas Instruments SN76489A Sound Generator," by Ted Mahler, Texas Instruments Application Report. Courtesy of Texas Instruments Incorporated.

"Advanced Circuits, SN 76489A," November 1981. Courtesy of Texas Instruments Incorporated.

"TMS9918A/9928/9929 Video Display Processor," 1981. Courtesy of Texas Instruments Incorporated.

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For further information or technical literature from Texas Instruments, write to: Texas Instruments Incorporated, Customer Response Center (1-214-995-6611). When requesting information, be as specific as possible and mention this article for best results.

Suppliers and Technical Information

The parts for this project may be ordered from:

Daniel G. Roy, 99 Andover St., Lawrence, MA 01843. 1-617-682-5132; 6:00-7:00 p.m.

CAI Instruments, PO Box 2032, Midland, MI 48640. 1-517-687-7343; orders: 9 a.m. to 4 p.m.; technical information 6-7 p.m.

Following is the parts list. Enquire concerning assembled price, power supply, and any options desired.

Complete kit of parts (PC board, documentation, PROM, and all necessary parts, less power supply): $159.95.

PC board, PROM, documentation: $59.95.

Connector, address decode, and buffers: $29.95.

Video: $49.95.

Joystick interfaces: $9.95.

Sound: $14.95.

Automatic jump circuitry: $4.95.

Parts List

Power Regulating Circuits

U29	LM350	1	+5 volts, 3 amps.
U25	LM317	1	+9 volts, 1 amp.
U26	7812	1	+12 volts, 1 amp.
U27	ICL7660	1	−5 volts, .1 amp.
	0.1 μf capacitor	2	
	10.0 μf capacitor	4	
	1.0 μf capacitor tant	2	
	1N4004	3	diode
	240 Ohm resistor 5%	2	
	TO-220 heat sinks	3	
	socket, 8 pin	1	
	5K variable resistor	2	

Motherboard, line buffer, and address decode circuitry

U1,2,3	74LS245	3	line buffers, bidirectional
U4	74LS367	1	line buffer
U5,6	6300-1J	2	256×4 programmed proms
U7	74LS08	1	2 input AND gate
U8,33	74LS138	2	3-to-8 decoder
U9	74LS02	1	2 input NOR gate
U28	74LS04	1	hex inverter
R1-R8		8	1K, 5% resistors
P0-P4		5	Sinclair 46 pin connectors
P5-P6		2	Radio Shack 44 pin connectors
		11	assorted 14,16,20 pin sockets

Sound Circuitry

U10	74LS373	1	8 bit latch with output enable
U31	76489A	1	TI sound chip
U30	74LS74	1	dual D-type flip flop
U32	LM 386	1	0.4 watt audio amplifier
	4,000 MHz	1	crystal
		1	1.0K, 5% resistor
		1	2.2K, 5% resistor
		1	10.0K, 5% resistor
		1	2.7K, 5% resistor
		1	10.0K, variable resistor
		1	0.1 μf capacitor
		2	250 μf capacitor, 25 volts
		1	10.0 μf capacitor, electrolytic
		4	assorted 8,14,16 pin sockets

Joystick Circuitry

U11	74LS373	1	8 bit latch with output enable
U24	CD4050	1	CMOS buffer
CC1A,B		2	component carriers (see Figure 7)
CC2A,B		2	component carriers (see Figure 7)
U22	LM339	1	dual comparator
U23	74LS367	1	buffer
		8	assorted 8,14,16 pin sockets
		2	dual 100K Ohm Radio Shack joysticks
		4	component carriers, 16 pin

Video Circuitry

U12	TMS9918A	1	TI VDP
U34-41	4116-150	8	4116 RAM chips, 16K×1, 150ns.
	10.7386 MHz	1	VDP crystal
		2	33 pf capacitors
VC1		1	9-35 variable capacitor
		1	1K variable resistor
		1	100 Ohm 5% resistor
	Um1082	1	RF modulator
		1	video monitor jack (optional)
		9	assorted 16,40 pin sockets

Prom and Automatic Jump Circuitry

U15	D2716	1	2K×8 bit prom, 5 volts only
U16	74LS74	1	dual D-type flip flop
U17	74LS00	1	2 input NAND gate
U18,19	74LS257	2	2 to 1 multiplexors
SW 1		1	8 position dip switch
		6	assorted 14,16,24 pin sockets

*also required, 49 pc. 0.01 μf decoupling capacitors

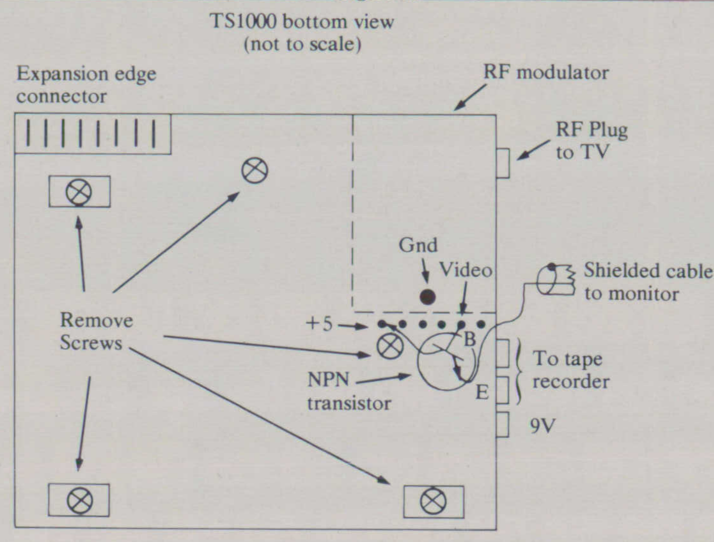
Connect a Monitor to the TS1000 *Cass R. Lewart*

Using a Timex/Sinclair 1000 with a video monitor instead of a TV set gives a dramatic improvement in the picture quality. This is particularly so with respect to the TS1000 graphic symbols.

Although the computer comes only with a standard RF output, it is comparatively easy to provide an additional monitor output. My modification requires only a single transistor: a Radio Shack 276-2009 or equivalent. No traces have to be cut on the TS1000 board. The result is a display with full brightness and contrast on any run-of-the-mill monitor. The modification should take no more than 10 minutes to perform.

To perform the operation, first remove the Phillips screws on the bottom of the computer (some of these screws are hidden under the rubber feet). Then make the soldered connections as shown in Figure 1. Tap the video input to the RF modulator and use one of the other two inputs as power supply (B+) for the transistor. To get B+ on the lead indicated, the computer channel switch must be kept in the Channel 2 position.

Figure 1.



The video voltage at the input to the RF modulator is approximately 1 Volt peak to peak. This would be sufficient to drive a monitor with sufficient contrast and brightness. However, the source impedance at this point is nearly 1000 Ohms. Therefore, a direct connection to a 50-75 Ohm monitor means a voltage drop to less than 100 mV. The result would be marginal brightness and contrast. The NPN transistor connected in the emitter follower configuration, as shown, provides the required impedance transformation, so that the full 1 Volt peak to peak reaches the monitor independent of the impedance of the monitor.

Next, decide where to mount the video monitor output jack. You can mount it next to the RF output, or, if you are not planning to use the RF output, you can use the RF jack and bypass the RF modulator. My own solution, though not a very neat one, was to let two wires dangle through one of the holes and to connect the wires to the monitor with clip leads.

Cass R. Lewart, 12 Georjean Dr., Holmdel, NJ 07733.

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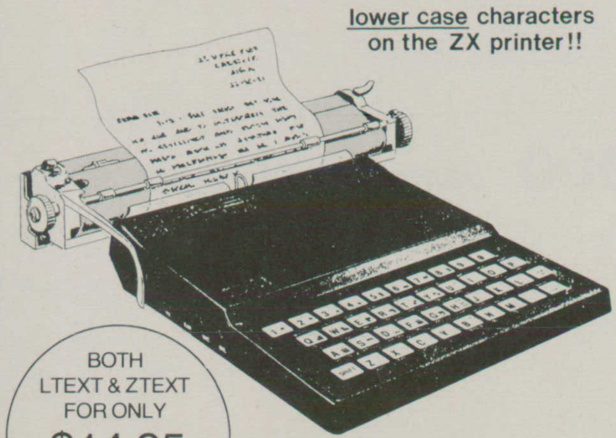

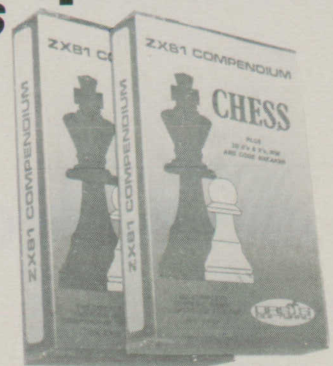

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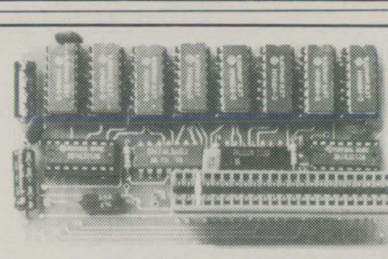

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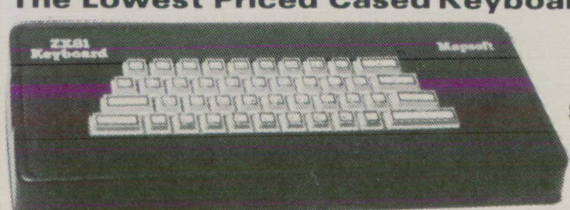

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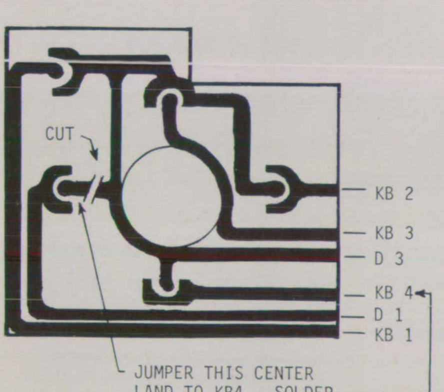
Adding A Joystick To The Timex-Sinclair 1000

James W. Stephens

Most active graphics programs for the TS1000/ZX81 use the unshifted cursor keys to control movement. Even though you can struggle your way through the program, this type of control is much like trying to drive an automobile using only a keyboard. It is just not natural.

After running my flight simulation program for a few days, I decided that I could probably improve my sloppy landings if I had a control stick.

Figure 1. Printed circuit board.

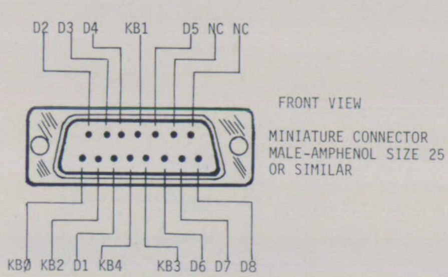


The Atari Controller

My son's Atari controller's plug fitted perfectly into the 15-pin RS232 connector that I used for my full-sized keyboard. Since the Atari stick is just a four-position switch, it seemed that a little rewiring to the connector would be all that was required.

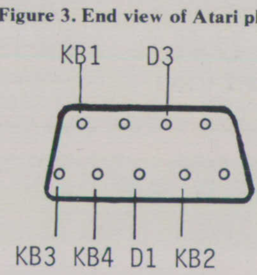
However, when I checked the Atari plug with an ohmeter, I discovered that several of the contacts were wired with a common line. The controller would have

Figure 2. Cable connector to ZX81.



to be rewired. As a result, it could no longer be used with the Atari VCS. So I went to our local Atari distributor and found that he had joysticks in stock for only $8.50.

Figure 3. End view of Atari plug.

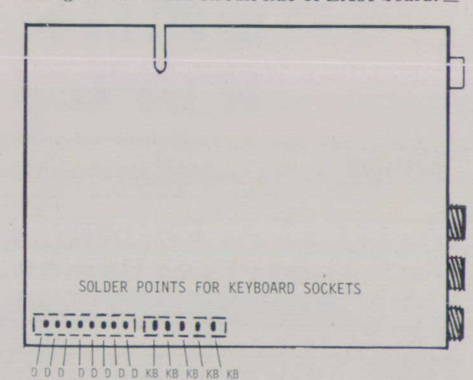


The controls of the stick are simple indent type buttons on a printed circuit board. The diagram in Figure 1 shows how these are mounted on the board. The movement of the stick pushes plastic fingers down to close either one or two of these contacts at a time. When I compared the circuit to those of the ZX81 cursor controls, I found that only one of the copper foils had to be cut and jumpered. This rewiring is as shown in Figure 1.

Converting the Atari Controller

All that is required to convert the controller is to cut gently the copper foil on the circuit board as shown in Figure 1 and jumper this switch connection over to the edge marked KB4. However, the proper connections must be made at the 15-pin connector as shown in Figure 2. The connector is then hard-wired into the ZX81 printed circuit board as shown in Figure 4. The male connector is wired directly to the original keyboard socket

Figure 4. Printed circuit side of ZX81 board.



connections by a short length of ribbon cable. This connector can be mounted into the top right-hand side of the case for good access.

Use great care when soldering to the socket pins since you will be very near small diodes which are sensitive to heat. Pre-tin your ribbon cable leads and solder bridges. Even though you do not need all the connections for the joystick, it is a good idea to wire all of the connections now since you may want to add a full-size keyboard later.

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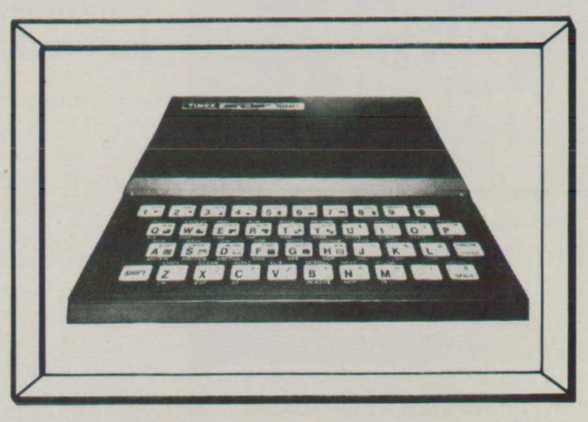

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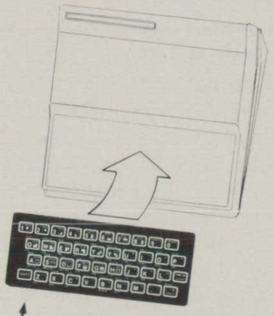

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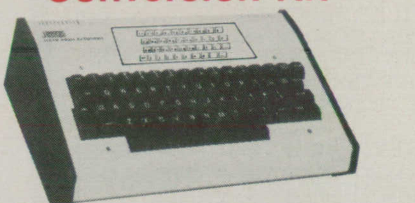

The JE682 Kit provides users of the ZX81/1000 series computers a full-size industrial keyboard hook-up to their computer. The JE682 Kit allows the use of either the full-size keyboard or the Sinclair/Timex Keyboard. The Kit also permits the simple disconnection of the Sinclair/Timex Keyboard for portable use. The JE682 Kit consists of a full-size industrial grade keyboard with 62 keys, 2 p.c. boards, 18" ribbon cable, DIP socket and 4 rubber feet. The keyboard conversion kit can easily be mounted into the DTE-AK enclosure. This enclosure is large enough to contain the ZX81/1000 computer and the full-size keyboard together. A handy label representing the ZX81/1000 keyboard layout is placed on the enclosure.

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your computer. Although it is rugged and can be reasonably handled, it is mainly made up of CMOS gates which can be permanently put out of action by a small static discharge. When working with CMOS circuits, I make it a policy *never* to wear sweaters or synthetic clothing or to work around plastic sheets, carpet, dogs, cats, or kids. Kids do not usually carry a lot of static charge, but they do have a tendency to drag all your parts into the floor when you are not looking. Try to discharge any static before touching the PC board. This can be done by touching a heavy metal object. Always use a high quality soldering pencil, preferably a grounded type, to insure against voltage transients from the iron.

Testing the Joystick

Plug the new controller into your connector and turn on the computer. A forward movement of the stick should produce a "7"and a backward direction will produce a "6." Left and right should produce a "5" and "8" respectively. I wired the "fire" button to "9" because it was convenient, but you can wire it to the character you prefer.

If you only get a blink of the cursor and no character, either you have shorted one of the matrix lines to each other or one of the switches in the joystick is stuck closed. If you get a wrong character, you have misconnected one of the KB and D lines. Remove the controller from the connector; entry from the original keyboard should return to normal.

The only big disadvantage to this arrangement is that a diagonal direction cannot be achieved. I feel, however, that with the combined use of the fire button, this function could be easily programmed.

Rewriting Existing Programs for the New Joystick

The improved operation of the flight simulation program was so dramatic that I decided to rewrite all of my graphic programs to respond to the cursor keys.

My screen drawing program, "Sketch-pad," is now a real joy to use. The three year-old from next door now loves "Sketch-pad," but he would not even try it with the keyboard. The program is shown in Listing 1 for those of you who would like to try your artistic hand with the new joystick. The "fire" button is used to select between either erasing or drawing. Pushing the button causes the pixel to erase itself as it is moved. Then, by pushing the button again, drawing can be continued. This handy little feature allows you to erase any errors or move the pixel to another location to start another line.

Listing 1. Sketch-pad program.

```
  5 REM "SKETCH-PAD"
 10 CLS
 15 PRINT "DRAW"
 20 PRINT "Z=CLEAR"
 25 PRINT "USE FIRE BUTTON FOR ERASE"
 45 LET X=30
 50 LET Y=20
 55 IF INKEY$="9" THEN GOTO 135
 60 IF INKEY$="7" THEN LET Y=Y+1
 65 IF INKEY$="6" THEN LET Y=Y-1
 70 IF INKEY$="5" THEN LET X=X+1
 75 IF INKEY$="8" THEN LET X=X-1
 80 IF INKEY$="Z" THEN RUN
 85 PLOT X,Y
115 UNPLOT X,Y
120 PLOT X,Y
125 GOTO 55
130 IF INKEY$="9" THEN GOTO 60
135 IF INKEY$="7" THEN LET Y=Y+1
140 IF INKEY$="6" THEN LET Y=Y-1
145 IF INKEY$="5" THEN LET X=X+1
150 IF INKEY$="8" THEN LET X=X-1
155 UNPLOT X,Y
160 PLOT X,Y
165 UNPLOT X,Y
170 GOTO 130
```

Most Basic programs use one or two methods to control the movement of the PRINT or PLOT command. This is usually done using the INKEY$ function and usually lets some variable equal PEEK 16421. This location is the storage area of the value obtained from the keyboard scan done after each TV frame. However, the code that is stored in this location is only a value that lets the computer know which *section* of the keyboard is being pressed. That is, the character 5 would have its own value but the characters 6 through 9 would all have the same code since they are all located in the same keyboard section. This method is slightly faster, but will work with the cursor controls. The PEEK method will have to be replaced with the INKEY$ function as in Listing 2.

Listing 2. Rewriting the PEEK method.

```
100 LET X = PEEK 16421
130 IF X=(239) THEN LET Y=Y+1

Change To:

130 IF  INKEY$ = (your character) THEN
    LET Y=Y+1

Delete line 100
```

You will find that the trouble of removing the case back and the soldering of the connector will be well worth the effort when you see how easily the graphics now respond.

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2K To 4K RAM Upgrade —An Introduction To ZX/TS Hardware

Randall S. Glidden

Introduction

Aside from the obvious fact that the TS1000 is an incredibly powerful computer for the money, it has a barebones simplicity in its hardware design that invites the user to explore and learn the hidden secrets of its digital circuitry. This hardware project will upgrade your on-board 2K RAM to 4K (or more) for under $10 and provide you with the opportunity to learn something of the elegance of computer electronics, with (hopefully) minimal risk of destroying your computer in the process.

Although this article applies to the TS1000 with 2K RAM, it will also work just fine with a ZX81 with the 2K RAM upgrade. (See J. Wayne Schneider's excellent article in *SYNC* 2:4 for 2K expansion details).

Hardware projects with the TS1000 are not really difficult since there are relatively few major components to deal with and the printed circuit board is laid out in a fairly logical fashion. It does, however, require more than just "cook book" knowledge to complete this project successfully—success being measured both by what has been accomplished and by what has been learned along the way. RAM expansion is a good example of a hardware modification that will give you exposure to some of the basic concepts of computer hardware design and function, and perhaps provide a foundation for further projects and experimentation. But most of all, I hope you will find that it is fun to get your hands on the circuits and make the computer do something new for you.

Part 1 of this article deals with the theory needed to understand the circuit modifications that will be made. It assumes that you know a little about binary numbers and simple electronics. If you want to learn the theory without voiding your warranty (which happens if you open up your computer during the warranty period), just read Part 2 which describes the construction and testing of the RAM expansion. Those of you who already understand all the concepts in Part 1 are excused to go immediately to Part 2.

Part 1

1) Binary

Since computer address and data lines are coded in binary, you need to know the binary system in order to understand how data is shuffled about in the TS1000. If you do not know binary, take the time to learn it before you begin.

2) Digital Circuits

Electronically speaking, binary logic l's and 0's can be represented by high and low voltages, respectively. In most digital circuits +5 volts = 1 and zero voltage (ground) = 0. This has been compared to a switch being either in the "on" or the "off" position; however, this is misleading. A digital logic zero should always be thought of as a wire connected to ground and not as a wire disconnected from voltage.

Another way to look at this is that a logic 1 *sources* +5 volts to a particular wire or device, while a logic 0 *sinks* voltage coming from that device to ground. Obviously, if a wire is connected neither to +5 volts nor to ground then it will be unable to source or sink current.

From this point on keep the following in mind:

5 Volts = logic 1 = high.

Ground = GND = 0 Volts = logic 0 = low

These will be used somewhat interchangeably.

3) TS1000/ZX81 Circuitry—Overview

The circuitry of the TS1000 can be divided into the following components (Refer to the photograph in your TS1000 *Basic Programming*):

a) Power source and +5 voltage regulator with a bunch of capacitors to provide a constant, smoothed, 5V power supply.

b) Z80A Central processing Unit (CPU): A 40 pin integrated circuit which performs all the "computing" functions. To make the Z80 ready to do Basic after you turn it on, it must receive operating instructions from the 8K ROM.

c) 8K ROM: A Read Only Memory which provides, in a sequential order, all the commands required so that the CPU can provide Sinclair Basic to the user. The commands are "byte" sized (i.e., decimal values 0 to 255) machine code instructions which occupy memory addresses 0 through 8191.

d) 2K RAM: Random Access Memory which is used for temporary storage of the program and the operating system variables (used by the ROM and CPU).

e) Sinclair Computer Logic chip: A conglomeration of logic gates and other circuitry which ties together the other components, generates the video display, provides circuitry for SAVE and LOAD, encodes the keyboard for the CPU, etc.

f) Miscellaneous stuff: VHF video modulator, clock circuits,

Randall S. Glidden, M.D., 185 Chiswick Rd., Brighton, MA 02135.

keyboard interface, expansion port, etc.

The functioning of all these components is beyond the scope of this article, but we do need to discuss how the Z80 CPU is tied in to the RAM and how to modify it to suit our purposes.

4) Z80 CPU

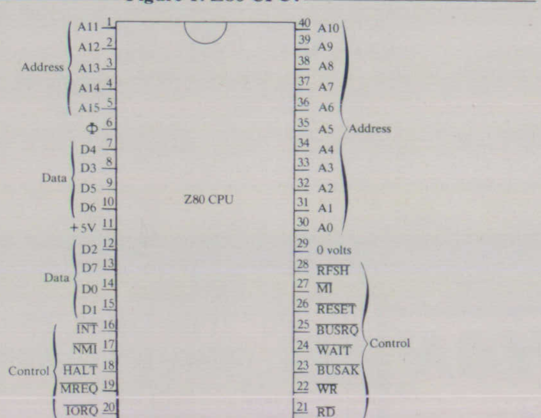
Most of the 40 pins of the Z80 can be divided into three groups (see Figure 1):

a) Control signals

Since these are the most difficult to deal with conceptually, we will ignore most of them. Suffice it to say that these carry signals either to the CPU (and therefore telling it to do something) or away from the CPU (and telling another device to do or get ready to do something). Without the control lines, the CPU would sit idly by, not knowing what to do next.

Let's consider $\overline{RD}$ and $\overline{WR}$ which are signals from the Z80. These can tell the RAM or ROM that the CPU wants either to ReaD something from memory or to WRite something (RAM only) into memory. The bar over the letters is read as "not WR," which means that during a write operation, when $\overline{WR}$ becomes active, a logic zero is present at that pin. I.e., if a device is to respond to that signal, it must be activated by a 0 and turned off by a 1.

Figure 1. Z80 CPU.



b) Address Bus

Sixteen separate, parallel lines (collectively called a bus) carry signals from the CPU to another device (RAM, ROM, etc.). They tell it the location of a particular byte of data. These lines are indicated by the abbreviations A0 through A15. The A0 line represents the least significant bit (LSB) of a 16 bit binary number, and therefore it can have the decimal value 1 or 0. A15 is the most significant bit (MSB) so, when it carries a 1, it has the decimal value 32768. Since all 16 lines can carry either a 1 or a 0, the address bus can code, in binary, any number from decimal 0 to 65535.

Transmission of an address along the address bus is done in a parallel fashion, i.e., if address 65535 is called for, then 1's appear simultaneously at all 16 of the address bus lines for a brief instant. Many of the address lines are connected to corresponding address pins of the memory devices, as you will soon see.

c) Data Bus

This is similar to the address bus in that it is a parallel set of lines which carry signals from the CPU. It differs in that it also carries data *to* the CPU (i.e., it is bidirectional). In addition, it has only 8 lines (D0 through D7) instead of 16. D0 is the LSB (equals 0 or 1, decimal) and D7 is the MSB (equals 0 or 128, decimal). So on the data bus, any number from 0 to 255 can be sent to or from the CPU.

d) Other pins

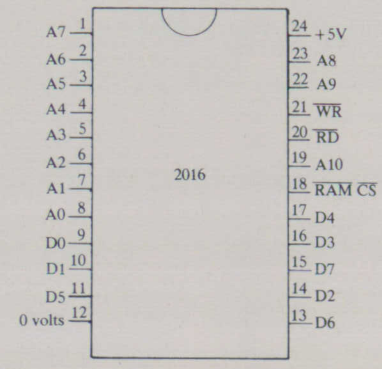
Besides a +5 volt and a ground pin, there is a clock input (marked Φ). This pin receives a 3.5 MHz pulse from the clock circuitry, thus providing the all important timing of the sequential steps the CPU must take, whether it is running a program or just sitting there with a K in the corner.

5) RAM: The Toshiba 2016

The TS1000 uses the 2016, a 24 pin, 2048 word x 8-bit, high speed static RAM. It can contain 2048 different bytes of memory or a total of 16384 different bits. It has the memory capacity of a two to three ton vacuum tube memory bank of the 1950s vintage and probably costs less than a single vacuum tube did back then!

The set-up of most of the 24 pins is similar to that of the CPU: 11 address bus pins (A0-A10), 8 data bus pins (D0-D7), 3 control pins, and +5 volt and ground pins. The 11 address lines will code for any number from 0 to 2047; the 8 data lines, for 0 to 255.

Figure 2. 2016 2K RAM.



The three control inputs simply tell the RAM chip what to do. $\overline{CS}$ is the *chip select,* and it is effectively the on/off switch for the chip. This pin is connected to a control line from the Sinclair Logic chip called $\overline{RAM\ CS}$. As before, the bar over "CS" means that it is active when this pin is low—i.e., the chip is *selected or enabled* when $\overline{CS}$ is low. When the chip is not needed, a logic 1 is present at $\overline{CS}$ and nothing happens.

Besides being turned off when CS = 1, the data bus lines will be in a high impedance state (also called *tristate*) at those times. This means that those lines are effectively disconnected from the rest of the circuitry—current will neither flow through nor from the data pins when $\overline{CS}$=1. The tristate concept is important since most, if not all, of the data and address buses are shared by so many different components. This effectively keeps them isolated from each other.

$\overline{RD}$ is the READ enable. When it is low, data from a particular location in memory is available to be placed on the data bus and thus READ by the CPU. $\overline{WR}$ is the WRITE

Table 1. Truth table for 2K RAM chip (TMM-2016 or equivalent).

$\overline{CS}$	$\overline{RD}$	$\overline{WR}$	Mode of Chip	Condition of data pins
1	X	X	Not selected (turned off)	High Impedence (tri-state)
0	0	1	READ	Data out
0	1	0	WRITE	Data in
0	0	0	WRITE	Data in

1 = +5 volts, high
0 = Ground (0 volts), low
X = Does not matter; could be 1 or 0

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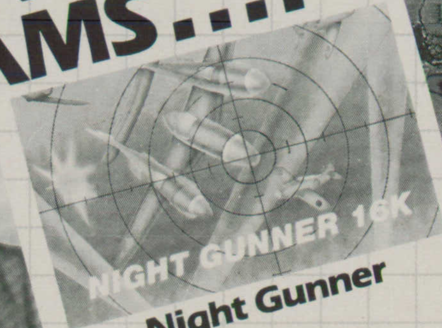

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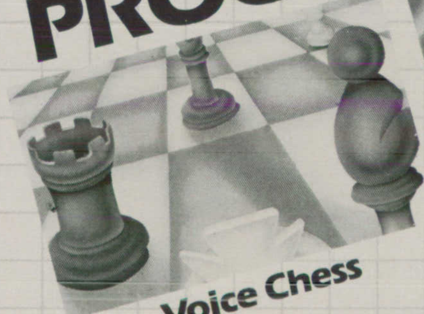

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enable. When it is low, data coming into the data bus can be written into a specified memory address. Since you cannot

Table 2. Memory address decoding.

Address Bus Line	Value (decimal)	Memory blocks: 1st 2048 bytes (16384-18431)	2nd 2048 bytes (18432-20478)	3rd 2048 bytes (20479-22526)
A15	2^{15}=32768	0	0	0
A14	2^{14}=16384	1	1	1
A13	2^{13}= 8192	0	0	0
A12	2^{12}= 4096	0	0	1
A11	2^{11}= 2048	0	1	1
A10	2^{10}= 1024			
A9	2^{9} = 512			
A8	2^{8} = 256			
A7	2^{7} = 128			
A6	2^{6} = 64			
A5	2^{5} = 32			
A4	2^{4} = 16			
A3	2^{3} = 8			
A2	2^{2} = 4			
A1	2^{1} = 2			
A0	2^{0} = 1			

Memory addresses occupied by each 2K RAM chip, i.e., 2048 bytes (0-2047) or any binary combination A0-A10

Summary of decoding for 8 2K Blocks.

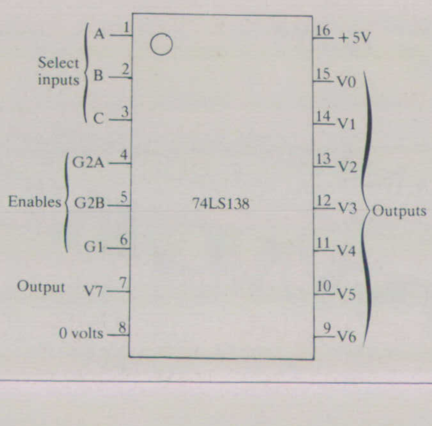
2K Block #	A11	A12	A13	A14	A15
1	0	0	0	1	0
2	1	0	0	1	0
3	0	1	0	1	0
4	1	1	0	1	0
5	0	0	1	1	0
6	1	0	1	1	0
7	0	1	1	1	0
8	1	1	1	1	0

Table 3. 74LS138 Truth Table.

INPUTs G2A	G2B	G1	C	B	A	OUTPUTs ($\overline{CS}$) 0	1	2	3	4	5	6	7	RAM chip #
1	X	X	X	X	X	1	1	1	1	1	1	1	1	-
X	1	X	X	X	X	1	1	1	1	1	1	1	1	-
X	X	0	X	X	X	1	1	1	1	1	1	1	1	-
0	0	1	0	0	0	0	1	1	1	1	1	1	1	1
0	0	1	0	0	1	1	0	1	1	1	1	1	1	2
0	0	1	0	1	0	1	1	0	1	1	1	1	1	3
0	0	1	0	1	1	1	1	1	0	1	1	1	1	4
0	0	1	1	0	0	1	1	1	1	0	1	1	1	5
0	0	1	1	0	1	1	1	1	1	1	0	1	1	6
0	0	1	1	1	0	1	1	1	1	1	1	0	1	7
0	0	1	1	1	1	1	1	1	1	1	1	1	0	8

1 = +5 volts, high
0 = Ground (0 volts), low
X = Does not matter; could be 1 or 0

Figure 3. 74LS138 1 of 8 decoder.



READ and WRITE data out of/into memory at the same time, the chip is set up so that $\overline{WR}$ must be high (i.e., inactive) when $\overline{RD}$ is low (active) in order for a READ to take place.

For a WRITE into memory to take place, $\overline{WR}$ must be low, but (for reasons of simplifying hardware design) $\overline{RD}$ can be high or low. In fact, the TS1000 ties $\overline{RD}$ permanently to ground; READ and WRITE operations are thus based entirely on the condition of $\overline{WR}$ (and $\overline{CS}$ of course). See Table 1.

In summary then, if $\overline{CS}$ is high, the 2016 is turned off and it does not matter what is present at $\overline{WR}$ or $\overline{RD}$. When $\overline{CS}$ is low, a WRITE into memory what is present at $\overline{WR}$ or $\overline{RD}$. When $\overline{CS}$ is low, a WRITE into memory will occur if $\overline{WR}$ is low, and a READ will occur if $\overline{WR}$ is high (since $\overline{RD}$ is *always* low anyway).

6) The Decoder

A RAM pack, such as the Sinclair 16K pack, consists of several separate memory chips wired together in parallel. From our examination of the 2016, it should be clear that in order to expand our on-board memory we must have some way of sequentially selecting the chips we add, just as the different RAM chips in a large memory pack are selected. This is done by a *decoder* circuit, a logic circuit which simply divides a large number of memory addresses among several discrete memory chips. In other words, suppose we have eight 2K RAM chips. We could have a total 16K of RAM if we had a circuit that would apportion that 16K into separate 2K chunks. In a more global sense, the decoder circuits in the TS1000 decide which of the 65535 potential addresses are locations in RAM, ROM, or whatever.

The TS1000 decoder is located in that giant Sinclair Logic chip, and basically does its work based on the condition of A14. The ROM is enabled if A14 = 0 (i.e., 0 to 16383, decimal), and the RAM is enabled if A14 = 1 (i.e., addresses 16384 and above). (A15 is used in the video display and prohibits use of the 32K memory block above 32767 without some special outside decoding circuits.) When RAM space is needed by the CPU, the decoder enables the on-board RAM by sending a "0" through the line $\overline{\text{RAM CS}}$, which is tied to the $\overline{CS}$ pin of the 2016. Since $\overline{\text{RAM CS}}$ is low at any address between 16384 and 32767, we can use $\overline{\text{RAM CS}}$ to help select any additional chips we may put in that space. What we must do, however, is provide for further decoding of that 16K block.

Table 2 shows the decimal representation of the value of each address line, A0-A15. If we are using 2048 byte chips that are all wired in parallel to A0-A10, all we have to do is use the status of the upper address lines (A11-A15) to decide for us which chip should be enabled for a specified location in memory.

The bottom portion of Table 2 shows that eight different chips, or a full 16K, can be selected using just A11, A12, and A13 (since there are eight combinations of a 3-bit binary number). Since A14 is always 1 and A15 is always 0 from 16K to 32K, we can ignore them and use just A11-A13. What we need is a circuit that will take a 3-bit binary number as input and give us eight different outputs that can be used to select our memory chips. Luckily someone invented the 74LS138!

7) The 74LS138

The 74LS138 is a 16 pin IC that functions as a "1-of-8 decoder/demultiplexer." The block diagram (Figure 3) and truth table (Table 1) give some idea of how it operates. As with the 2016, this chip must also be enabled to be functional. It differs in that there are *three* different enable inputs, two active when low (pins 4 and 5), and one active when high (pin 6). The truth table shows that, unless pins 4 and 5 are low *and* pin 6 is high, the outputs at V0-V7 will all be high, regardless of the condition of the three inputs: A, B, and C. When the chip is enabled, different inputs at S, B, and C (from 000 to 111, binary) produce a logic 0 at one of the eight outputs, V0-V7.

Now, if we connect A11, A12, and A13 to inputs A, B, and C, respectively, and then connect the "V" outputs sequentially to our 2K RAM chips, we will have our decoding problem almost solved. To enable the 74LS138 itself we can use the $\overline{RAM\ CS}$ line from the logic chip and connect it to enable pins 4 and 5 (remember, active low). To keep the "high" enable high we can just permanently connect pin 6 to +5 volts. To make matters even simpler, if you are only adding one or two extra 2K chips, you can skip the connection to A13, since this is a 0 for the first four 2K blocks anyway. Just connect input C to ground, in that case, making *it* a permanent 0.

Congratulations! If you have made it through all that, you could probably do the memory expansion project without reading any further, since all we have to do is connect the 74LS138 to GND, +5 volts, $\overline{RAM\ CS}$, A11, and A12 on the TS1000 circuit board, and connect two of the 74LS138 output pins to the $\overline{CS}$ pins of two 2K RAM chips stacked on top of each other. All you really need to know now is the location of the necessary lines on the circuit board and some of the practical construction points. These will be covered in Part 2.

Part 2

Now we will dive into the actual construction details of our RAM expansion. Hopefully you are already familiar with which end of a soldering iron gets hot, and perhaps you already have some (or all) of the equipment listed below. Since it is a little tricky soldering connections directly to integrated circuit pins, I recommend that you buy an inexpensive wire-wrapping tool and make the connections that way. Provide yourself with a clean, well lit work space, get together all the necessary materials, and have fun!

Materials

1) A 2Kx8 static RAM. Although I have discussed the Toshiba 2016 above, I recommend the Hitachi, HM 6116LP-4. JDR Microdevices, Inc. sells the 6116LP-4 for $6.95 (at the time of this writing). You can get a 6116-4 (not LP, low power) for $4.95, but it uses slightly more power—a consideration if overheating is often a problem. The 2016 (TMM 2016-200) is the cheapest 2Kx8 RAM on JDR's list, selling for a mere $4.15. It does, however, use more power than any of the 6116s, but all the pin designations are exactly the same.

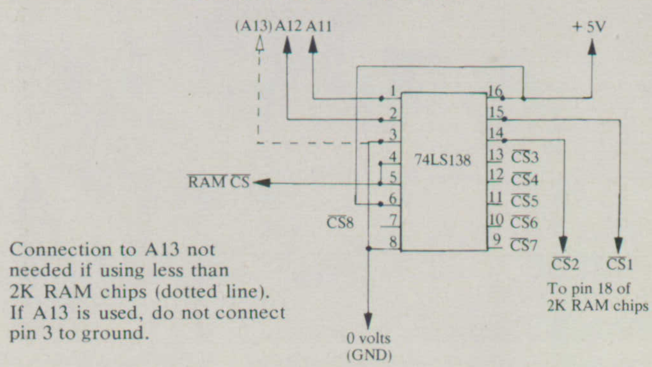
Note that when you see a catalog listing of these chips you will see that the access times are listed in many cases. For example, a 6116-4 has an access time of 200 nanoseconds while a 6116-2 has an access time of 120 nanoseconds. The Z80 CPU uses about 900 nanoseconds to access a RAM chip, so it is not necessary to spend more money for the faster chips; better to get the low power RAM and save on power requirements instead.

By the way, I recommend JDR as a source for IC chips because they always have a catalog type ad at the back of every issue of *Computers and Electronics* (formerly *Popular Electronics*), they have a toll-free number for charge card orders (800/662-6279; California only), their prices are as low as you are likely to find, and they ship fairly quickly. They do have a $10 minimum order, which is more than you will need to spend in parts for this whole project! But you can stock up on a few other parts to pad out your order. Their address is: JDR Microdevices, Inc., 1224 S. Bascom Ave., San Jose, CA 95128.

2) A 74LS138, 1-of-8 decoder. $.55 from JDR or $.99 from Radio Shack.

3) A 16-pin solder-tail DIP IC socket. $.17 from JDR.

Figure 4. Decoder wiring diagram.



4) 30 gauge wire-wrap wire. Radio Shack 278-500 series, or equivalent.

5) Double-sided tape or rubber cement.

6) Rosin-core solder.

Tools

1) A 15-25 watt fine-tipped soldering iron.

2) A small wire-wrapping tool. Radio Shack 276-15700, or equivalent.

3) A sharp, fine pointed knife, e.g., X-acto.

4) A small Phillips-head screw driver.

5) Needle-nose pliers.

Construction Overview

You will see from the schematic (Figure 4) that all we are doing is wiring the 74LS138 to the board and connecting two (or more) of its outputs to the $\overline{CS}$ pins of two (or more) stacked 2K RAM chips. The connections to the 74LS138 will be made by wire-wrapping directly to its pins and making a few solder connections to the TS1000 circuit board. To hold the chip in place we will use a 16-pin DIP socket with its pins removed and its socket holes enlarged with the X-acto knife accommodate the wire-wrapped IC pins. The 74LS138 in its socket will be attached to the board in the space between the RAM and the CPU using either double-sided tape or rubber cement. The RAM chips will be stacked on top of each other, with the upper chip pins bent inward slightly to make contact with the lower chip pins. The $\overline{CS}$ pins will be bent outward, and connected to the 74LS138 with wire-wrapping connections.

Step-by-Step Construction

1) Remove the TS1000 circuit board from the case.

Turn the computer upside down so that the expansion port is pointed away from you. Remove the five Phillips head screws, three of which are under the lower two and upper left rubber pads. Remove the pads carefully and set aside. Note that the lower two screws are shorter than the upper three, and be sure you put them back that way when you are done. Remove the back and set it aside.

2) Remove the circuit board.

Remove the two screws holding the board in place, noting their position. Turn the board over and carefully pull the keyboard tails out of the board connectors. (Do not bend or kink the tails in the process.)

3) Locate the land marks.

With board oriented in the same way as the photograph (Figure 5) locate the 2K RAM chip, the CPU, and the expansion edge connector strip. Since the TS1000 uses the same board as the ZX81, do not be surprised when you see "Sinclair ZX81" stamped in the upper right-hand corner! Between the CPU and the RAM chip is a space marked IC4a. This was used in many ZX81s as half of the 1K memory, since

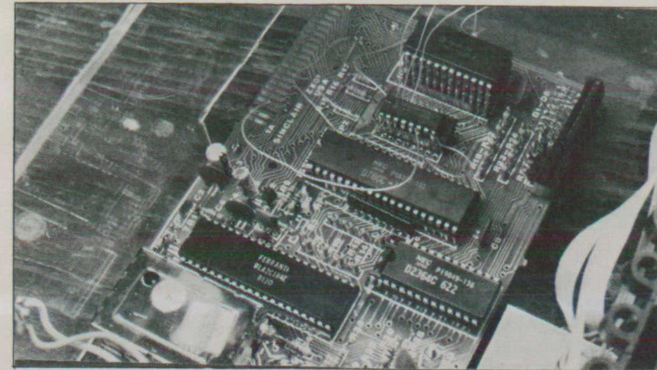


Figure 5. TX/TS circuit board with added 74LS138 and 3 stacked 2K RAM chips.

those had two 1028 x 4 bit chips instead of a single 1028 x 8 chip.

4) Wire the 74LS138.

Practice making a few wire-wrap connections on some spare parts. Then you can make the connections shown in Figure 4. First connect pin 16 (+5 volts) to pin 6 (the permanent 1 enable), and then connect pin 3 (input C) to pin 8 (ground) using short wire wrap connections. (Recall that for the first four RAM chips we do not need A13, which would be input C. We will just hook it to ground, making it a permanent 0.)

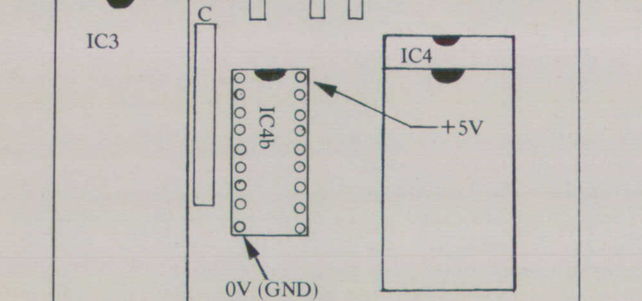
Prepare seven 2 to 3 inch lengths of wire-wrap wire with 1/4" insulation stripped from one end and 1/2" stripped from the other. Wire-wrap the 1/2" ends to pins 1, 2, 4 and 5 (together), 8, 14, 15, and 16. (If you are stacking more than one RAM chip, you will need additional wires at pins 13-9, as shown in the schematic.)

5) Prepare the socket.

With a pair of pliers pull all the solder-tail pins out of the 16 pin DIP socket. They should pull right out. With the X-acto knife enlarge the socket holes wherever a pin with wire-wrap is to be placed, and then see if your wired 74LS138 will fit into it. You will probably have to bend the pins inward a bit to do this. You should get a nice snug fit so that the IC will not pop out of the socket when you put the computer back together.

6) Solder the 74LS138 to board.

Figure 6. Location of holes for solder connections.



Labels correspond to those found on the TS1000 or ZX81 circuit board.

You will need to make five solder connections to the circuit board. As long as you do not touch the tip of the soldering iron to the ICs on the board you should cause no damage while soldering, so I do not recommend you remove all four ICs. It is helpful to have your TS1000 operable during this part of the construction so that you can turn it on after each solder connection and see if it still works, as a solder short will yield a blank or broken screen. This makes trouble shooting much easier.

With the power to the computer off, place each wire from the 74LS138 in turn into its appropriate hole as shown in Figure 6, and solder it in place, using as little solder as possible. (Hint—tinning the ends of each wire with solder beforehand allows two-handed soldering, rather than the usual "three-handed" method.) Be careful the solder has not shorted across to another circuit tracing—check each side of the board for this. After each soldered connection test the computer by hooking it to the TV and applying power—you do not need the keyboard hooked up to get a K cursor. If at any point the K does not appear after you have made a connection, do not panic. Just check the connection carefully and resolder if necessary.

7) Stack the RAM chips.

Take the RAM chip you are going to add, and orient it over the on-board RAM chip. Locate the dent at the top end of the chip so that it lies above the dent end of the board RAM chip. You will see that the pins of your upper chip probably do not make contact with the lower chip pins. Place the edge of the chip on a flat surface and apply gentle downward pressure to bend all the pins on one side inward slightly. Repeat this on the other side and try stacking the chip again. Continue bending the pins inward, a little at a time, until all the pins make firm contact with the pins of the lower chip. Since the RAM chips are wired in parallel, except for the CS pins, this snug fit is of the utmost importance for success.

Now locate the $\overline{CS}$ pin (pin 18), and bend it outward so that it is at a right angle to the other pins. Now replace the chip in its protective foam for now and set it aside.

Carefully remove the on-board 2016 RAM chip by alternatively prying up at each end with a small screwdriver. Be careful not to bend the pins. Locate pin 18 again ($\overline{CS}$) and bend it outward as you did with the chip to be added. Replace the 2016, with pin 18 sticking out sideways, out of its socket.

8) Final connections and testing.

Wire-wrap the wire from pin 15 of the 74LS138 decoder to pin 18 of the on-board RAM. Power up the computer and see if it works, now that the on-board chip is connected to the decoder. If it does not work, go to the "Trouble shooting." If it works, pat yourself on the back and then wire-wrap pin 18 of the other RAM chip to the decoder pin 14, and stack the chip on top of the on-board chip. Be sure that all the pins are making firm contact with each other (except, of course, pin 18). Although Figure 5 shows three 2K chips stacked together, your board should now look similiar.

Apply power again and see what happens. After a delay of about 3-4 seconds you should see the K cursor appear. Now comes the moment of truth: reconnect the keyboard tails and check the memory RAMTOP setting by typing in:

PRINT PEEK 16389*256-16384

You should then see 4096, the amount of RAM available. If that is what you get, then pat yourself on the back again, have a beer, and go show your wife/husband/significant other the wonderful thing you have done. If you get 2048 that just means your added RAM chip is not making firm contact with all the pins; reposition it and try again.

9) Reassembly.

After playing with your new 4K RAM a bit, you will probably want to anchor the added RAM chip to the board

chip either by applying double sided tape to its side or by gluing with a *thin* layer of rubber cement. This will keep the chip from popping off after reassembly. I would advise against using epoxy or super glue, since it is possible you may want to remove or adjust the placement slightly in the future without the aid of a hammer and chisel.

Some people with much CMOS expertise may wish to solder the two chips together. This is dangerous to the life of your RAM chips unless you have had considerably more experience than most in doing this. You must use a soldering iron with a grounded tip and be a bit more cavalier than I am to attempt it; so do so at your own risk!

Now attach the 74LS138 socket to the board using double sided tape or rubber cement. Make sure none of the IC pins are extending through the socket; this could cause a short. You may want to insulate the socket with some electrician's tape to safeguard against this.

Try to tuck the wires from the decoder out of the way, since the keyboard tails will be lying directly over it when the computer is reassembled.

Now, make sure the added RAM still works, and the replace the circuit board in the case and close up. Be sure you use the proper screws. Reattach the rubber feet, using rubber cement if needed.

Beyond 4K

If you have your circuit board mounted inside some kind of big keyboard enclosure with enough room, you can stack up to eight chips (in theory at least—I have stacked only three). Just bend out pin 18 of each chip and wire-wrap one of the other output pins from the decoder to it. If you do this, I would especially advise using the 6116-LP4s, keeping the power requirements to a minimum. Unfortunately, there is only room for one extra chip under the hood of a standard TS1000.

Trouble Shooting

The following problems are the ones you will most likely encounted.

1) K cursor will not appear or zig-zag lines appear. Look for solder shorts and for poor solder connections. Are all the solder connections made in the correct holes? Also beware of steel wool dust—a common work shop containment. It can microscopically short across some of the closely spaced traces.

Make sure you wired the 74LS138 correctly and that none of the wire-wrap connections are shorting each other out. (You did not wire the chip backwards, did you?) Also make sure you wired the decoder to pin 18 of the RAM chips.

If all else fails, it is possible you have a bad 74LS138; get another and try again. (This does not happen very often.)

2) Can only get 2K of RAM. Make sure all the RAM pins are making firm contact with each other. Try bending them all in a bit more. Make sure that pin 18 of one RAM is not touching that of the other RAM. See that the connections from the decoder to the chips are good.

3) If you have any other trouble please send me a description of your problem along with a self-addressed stamped envelope, and I will try to help you if I can.

Conclusion

Well, that is about it. I hope that your RAM expansion has been successful, and that you will now want to try your hand at other hardware projects. Having an expansion board is the best way to take on serious hardware design, since all construction is done on separate boards, thus posing less risk to your main computer circuits.

I welcome any comments, constructive or otherwise, from *SYNC* readers.

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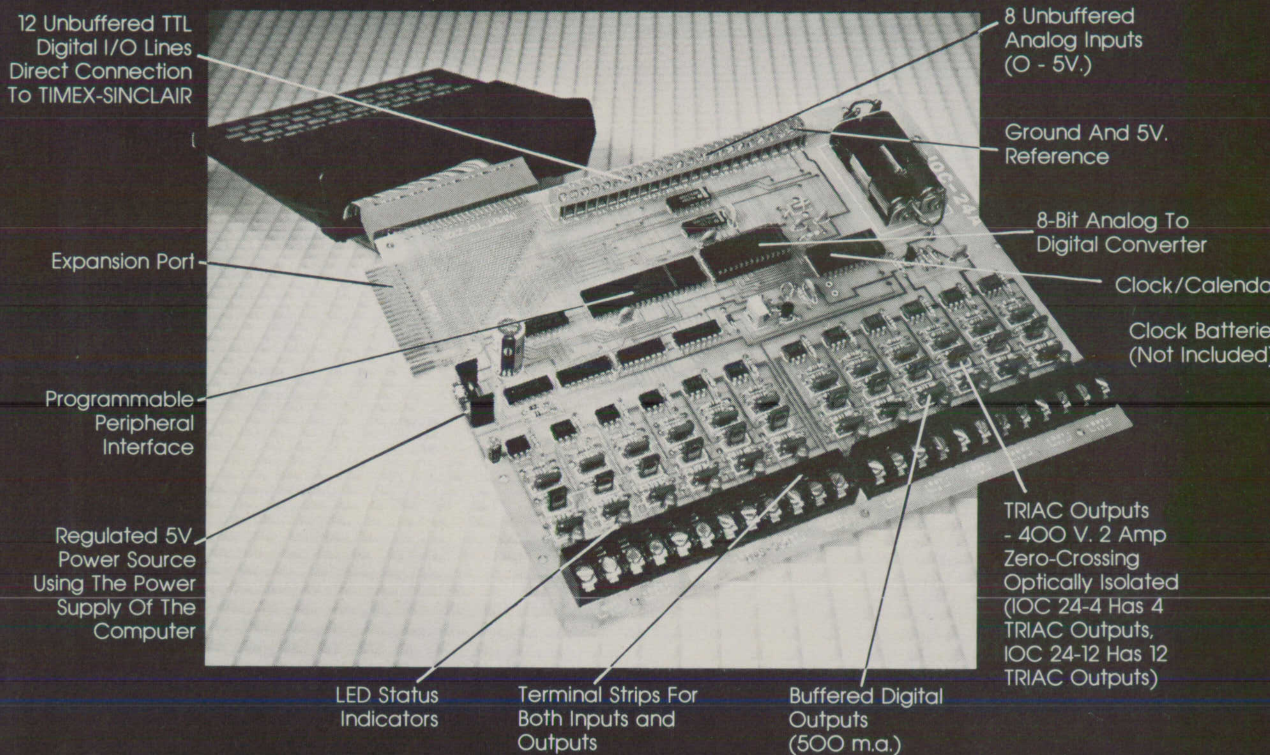

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Stringing along with the ZX81 *Paul J. Wentink*

The DATA-READ statement is the basic computer command for the efficient storage and use of data comprised of many values (bulk data) where data is to be used repetitively in a program or where data is to be retained for successive computer runs. Such data might consist of names and addresses, names and phone numbers, football scores, degree days, inventory part numbers, star brightness intensity, input from an RS232 port, and on and on and . . .

As we are aware, the ZX81 does not include these statements. The *ZX81 Basic Programming* manual by Steven Vickers suggests the use of LET X=N type statements to duplicate DATA statements. This, unfortunately, requires the extensive dedication of memory for data storage except for short programs. Another method of achieving a ZX81 DATA-READ capability would be through machine language. This would require a very thorough knowledge of the Z80 CPU assembly language. There is, however, a method of simulating DATA-READ statements on the ZX81 using string statements, slicing, and the LEN/VAL functions. This method does not require the use of machine language nor does it require excessive memory. Furthermore, it can be easily mastered if the use of string statements as presented in the *ZX81 Basic Programming* manual is understood.

The proposed method consists of entering data as a string statement, slicing the characters from the string which make up a data-set, converting the sliced substrings to a numerical value, if necessary, and then using these substrings as program variables.

The ZX81 DATA-READ simulation technique is generally developed in accordance with the following steps:

Step 1. Enter all data in a string statement (LET A$="XXXX") so that each data-set within the string can be identified repetitively by character position within the string.

Step 2. Set up an array which will permit each data-set to be assigned a unique address in the array as it is sliced from the string, or originate statements which will selectively slice data-sets from the string to be used directly as program variables.

Step 3. Read data-sets from the array or string as applicable, convert data to numeric values if necessary and use as program variables.

Since data entered in a program using this method is always directly addressable, there is no need for the RESTORE command which is usually associated with Basic DATA-READ commands.

To demonstrate the ZX81 DATA-READ simulation technique, five programs are presented of varying complexity showing first the DATA-READ program in Basic Language which is not usable with the ZX81 Computer, and then equivalent programs written for use with the ZX81. Program Listings 1A through 1E are all equivalent programs consisting of a data statement containing a number of data-sets from which data is read and then used in a simple arithmetic calculation. Program Listings 2A through 2C are all equivalent programs demonstrating a ZX81 DATA-READ simulation for data which is NON-NUMERIC. Program Listings 3A through 5B are a series of three similar programs of increasing complexity wherein a data-set counting program tallies the number of times a data-set of like value occurs in a data statement.

Listing 1A. Conventional Basic READ-DATA Program.

```
05 REM LISTING 1A
10 READ A,B,C,D
20 PRINT A+B,C+D
30 DATA 5,10,15,20
```

```
15        35
```

Paul J. Wentink, 36102 S.E. 49th St., Fall City, WA 98024.

Program 1

Listing 1A is a program written in conventional Basic using DATA-READ statements which cannot be executed on a ZX81 Computer.

Listing 1B is a program, equivalent to listing 1A, which can be executed on a ZX81 Computer. The program simulates a DATA-READ capability by entering the data as a string statement with all data-sets expressed as two characters separated from other data-sets with commas for visibility (line 10).

Listing 1B. ZX81 Simulation of DATA-READ Statement Using a Fixed Size Addressable Array.

```
05 REM LISTING 1B
10 LET A$="05,10,15,20,"
20 DIM A(4)
30 LET X=1
40 FOR J=1 TO 4
50 LET Y=X+1
60 LET A(J)=VAL A$(X TO Y)
70 LET X=X+3
80 NEXT J
90 PRINT A(1)+A(2),A(3)+A(4)
```

```
15        35



0/90
```

An array is then dimensioned to accept the data-sets so that each can be addressed by name when used as a program variable (line 20). The data is sliced from the string and entered by value into the array (lines 30-80). Numerical calculations are then made using the data as addressed within the array (line 90).

Listing 1C is the same program as Listing 1B except that the array is not dimensioned for a fixed size but is set up equal in size to the number of data-sets existing in the program.

Listing 1C. ZX81 Simulation of DATA-READ Statement Using a Variable Size Addressable Array.

```
05 REM LISTING 1C
10 LET A$="05,10,15,20,"
20 DIM A(LEN A$/3)
30 LET X=1
40 FOR J=1 TO LEN A$/3
50 LET Y=X+1
60 LET A(J)=VAL A$(X TO Y)
70 LET X=X+3
80 NEXT J
90 PRINT A(1)+A(2),A(3)+A(4)
```

```
 15        35

 Ø/9Ø
```

Each data-set, again, is expressed as two characters separated by a comma. Thus the array size must equal the total number of characters entered into the data string divided by 3 or LEN A$/3 (line 20). Since the size of the array will now adjust to the number of data-sets in the data string, the program loop entering the data into the array must likewise vary in length. This is accomplished by entering LEN A$/3 into the loop command (line 40).

Listing 1D is the same as Listing 1C except that new data has been added to the program in a new string command (line 901), the original A$ command has been adjusted to include the new B$ data (line 990) and the variable size array has accepted the new data without revision to the program. Thus new data has been added without need to re enter previous data or making any program deletions. It should be evident that additional new data entries can be made in like manner by entering up to 26 new data strings of any length, i.e., C$,D$, etc, and then including those strings in line 990. For example:

```
900 LET A$="05,10,15,20,"
901 LET B$="25,30,35,40,"
902 LET C$="45,50,"
903 LET D$="55,60,65,70,75,80,85,"
990 LET A$=A$+B$+C$+D$
999 GOTO 20
```

Listing 1E is the same program as Listing 1B except that the data is not addressable within an array but is rather sliced from the data string and used directly as substrings as program variables.

Program 2

Listing 2A is a program show in the *ZX81 BASIC Programming* manual as an example of ZX81 incompatibility with conventional Basic DATA-READ statements.

Listing 2B is a program equivalent to Listing 2A which can be executed on a ZX81 Computer. The simulation of a ZX81 DATA-READ program follows the same technique as explained for Listing 1B except that the data is non-numeric and can therefore be used as a program variable as entered in the

Listing 1D. ZX81 Simulation of DATA-READ Statement Using a Variable Size Addressable Array with New Data Addition.

```
 05 REM LISTING 1D
 10 GOTO 900
 20 DIM  A(LEN A$/3)
 30 LET X=1
 40 FOR J=1 TO LEN A$/3
 50 LET Y=X+1
 60 LET A(J)=VAL A$(X TO Y)
 70 LET X=X+3
 80 NEXT J
 90 PRINT A(1)+A(2),A(3)+A(4),
          A(5)+A(6),A(7)+A(8)
100 STOP
900 LET A$="05,10,15,20,"
901 LET B$="25,30,35,40,"
990 LET A$=A$+B$
999 GOTO 20
```

```
 15        35
 55        75



 9/10Ø
```

Listing 1E. ZX81 Simulation of DATA-READ Statement Using Data Directly Addressable within the Data String.

```
05 REM LISTING 1E
10 LET A$="05,10,15,20,"
20 PRINT VAL A$(1 TO 2)+VAL A$(4 TO 5),
      VAL A$(7 TO 8)+VAL A$(10 TO 11)
```

```
 15        35
 Ø/2Ø
```

Listing 2A. Conventional Basic DATA-READ Program.

```
05 REM LISTING 2A
10 REM THIS PROGRAM WILL NOT WORK
   IN ZX81 BASIC
20 DIM M$(12,3)
30 FOR N=1 TO 12
40 READ M$(N)
50 NEXT N
60 DATA "JAN","FEB","MAR","APR"
70 DATA  "MAY","JUN","JUL","AUG"
80 DATA "SEP","OCT","NOV","DEC"
```

string without need for VAL function conversion. It should be noted that the commas used in the data string (line 10) are used only for making the data readable. For computer purposes, the commas as shown serve no purpose

Listing 2B. ZX81 Simulation of DATA-READ Statement Using a Fixed Size Addressable Array with Non-Numeric Data.

```
 05 LISTING 2B
 10 LET D$="JAN,FEB,MAR,APR,
            MAY,JUN,JUL,AUG,
            SEP,OCT,NOV,DEC,"
 20 DIM M$(12,3)
 30 LET X=1
 40 FOR N=1 TO 12
 50 LET Y=X+2
 60 LET M$(N)=D$(X TO Y)
 70 LET X=X+4
 80 NEXT N
 90 FOR N=1 TO 12
100 PRINT TAB (5*N)-3;M$(N)
110 NEXT N
```

```
 JAN
     FEB
         MAR
             APR
                 MAY
                     JUN
 JUL
     AUG
         SEP
             OCT
                 NOV
                     DEC

 Ø/11Ø
```

Listing 2C. ZX81 Simulation of DATA-READ Statement Using a Fixed Size Addressable Array with Non-Numeric Data and Array Content Printout within Loop.

```
05 REM LISTING 2C
10 LET D$="JAN,FEB,MAR,APR,
           MAY,JUN,JUL,AUG,
           SEP,OCT,NOV,DEC,"
20 DIM M$(12,3)
30 LET X=1
40 FOR N=1 TO 12
50 LET Y=X+2
60 LET M$(N)=D$(X TO Y)
70 PRINT "M$(";N;")=";M$(N)
80 LET X=X+4
90 NEXT N
```

```
M$(1)=JAN      M$(2)=FEB
M$(3)=MAR      M$(4)=APR
M$(5)=MAY      M$(6)=JUN
M$(7)=JUL      M$(8)=AUG
M$(9)=SEP      M$)10)=OCT
M$(11)=NOV     M$(12)=DEC


Ø/9Ø
```

and could be deleted. However, it is possible to use such characters as data recognition flags. In this case they would be required.

Listing 2C is the same program as Listing 2B except that the data array is printed out as the data array loop is executed. This program routine is useful to display the contents of the array but does not serve any program need. If the print statement (line 70) is not executed, the data will still be entered in the array as program variables.

Listing 3A. Conventional Basic DATA-READ Program.

```
05 LISTING 3A
10 DIM C(2)
20 LET C(1)=0
30 LET C(2)=0
40 READ A
50 IF A=-1 THEN 80
60 LET C(A)=C(A)+1
70 GOTO 40
80 PRINT C(1),C(2)
900 DATA 1,1,2,1,1,2,2,1,1,1,-1
```

```
7          3
```

Program 3

Listing 3A is a program written in conventional Basic using DATA-READ statements which cannot be executed on a ZX81 Computer.

Listing 3B is a counting routine using a single-subscripted variable array. The array diagram is shown in Figure 1. As shown by the diagram, each data-set consists of one variable, "A". A running total is made of data-sets equal in value to 1 or 2 which are addressed as variables C(1) and C(2) respectively. Thus, in the data string (line 40) there is a total of 20 characters. There are 10 data-sets, 7 of which are equal to 1, and 3 of which are equal to 2. The arrangement of data in the DATA STRING is as follows: 40 LET C$="A,A,A,etc"

Listing 3B. ZX81 Simulation of DATA-READ Statement for Single-subscripted Variable Array in Data Count Program.

```
05 LISTING 3B
10 DIM C(2)
20 LET C(1)=0
30 LET C(2)=0
40 LET C$="1,1,2,1,1,2,2,1,1,1,"
45 PRINT "LENGTH OF C$=";LEN C$,,
      "DATA COUNT =";LEN C$/2
50 LET D=2
60 LET A=1
70 LET X=1
75 FOR N=A TO LEN C$/D
80 LET J=VAL C$(X)
85 LET C(J)=C(J)+1
90 LET X=X+2
100 NEXT N
110 PRINT
120 PRINT "C(1)","C(2)"
130 PRINT C(1),C(2)
```

```
LENGTH OF C$=2Ø
DATA COUNT=1Ø

 C(1)       C(2)
 7          3



Ø/13Ø
```

Figure 1. Array Diagram for Listing 3B.

A=1	C(1)
A=2	C(2)

Program 4

Listing 4A is a program written in conventional Basic using DATA-READ statements which cannot be executed on a ZX81 Computer.

Note: Lines are numbered as shown to save memory for 1K RAM.

Listing 4A. Conventional Basic DATA-READ Program.

```
05 REM LISTING 4A
10 DIM C(3,3)
20 FOR Y=1 TO 3
30 FOR Z=1 TO 3
40 LET C(Y,Z)=0
50 NEXT Y
60 NEXT Z
70 READ J,K
80 IF J=-1 THEN 110
90 LET C(J,K)=C(J,K)+1
100 GOTO 70
110 PRINT C(1,1),C(1,2),C(1,3)
120 PRINT C(2,1),C(2,2),C(2,3)
130 PRINT C(3,1),C(3,2),C(3,2)
900 DATA 1,2,1,1,2,1,2,2,3,3,3,1,2,3,
    1,3,1,3,2,1,3,1, 3,3,3,3,-1,-1
```

```
1          1
2
2          1
1
2          Ø
3
```

Listing 4B is a counting routine program equivalent to Listing 4A using a double-subscripted variable array. The array diagram is shown in Figure 2. A running total of all like data values are entered and counted in the array addresses as shown in the array diagram.

Listing 4B. ZX81 Simulation of DATA-READ Statement for Double-Subscripted Variable Array in Data Count Program.

```
1 REM LISTING 4B
2 DIM C(3,3)
3 FOR Y=1 TO 3
4 FOR Z=1 TO 3
5 LET C(Y,Z)=0
6 NEXT Z
7 NEXT Y
8 LET C$="1,2;1,1;2,1;2,2;3,3;
       3,1;2,3;1,3;1,3;2,1;
       3,1;3,3;3,3;"
10 PRINT "DATA-SETS =";LEN C$/4
20 LET J=1
30 FOR N=1 TO LEN C$/4
40 LET K=J+2
50 LET Y=VAL C$(J)
60 LET Z=VAL C$(k)
70 LET C(Y,Z)=C(Y,Z)+1
80 LET J=J+4
90 NEXT N
95 PRINT C(1,1),C(1,2),C(1,3)
96 PRINT C(2,1),C(2,2),C(2,3)
97 PRINT C(3,1),C(3,2),C(3,3)
```

```
DATA-SETS =13
1              1
2
2              1
1
2              Ø
3

Ø/97
```

Figure 2. Array Diagram for Listing 4B.

	B=1	B=2	B=3
A=1	C(1,1)	C(1,2)	C(1,3)
A=2	C(2,1)	C(2,2)	C(2,3)
A=3	C(3,1)	C(3,2)	C(3,3)

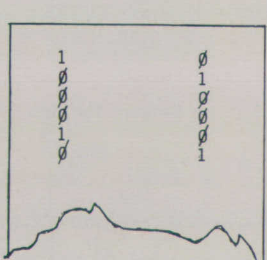
Each data-set consists of two data values (A and B), a data separating comma and a closing semi-colon. Thus in the data string (LINE 8) there are 13 data-sets consisting of 4 string characters each for a total string length of 52 characters (4 X 13 = 52). The data-set length for program commands (line 10 & line 30) is then LEN C$/4. The arrangement of data in the DATA STRING is as follows: 8 LET C$="A,B;A,B;A,B; etc."

Program 5

Listing 5A is a program written in conventional Basic using DATA-READ statements which cannot be executed on a ZX81 Computer.

Listing 5A. Conventional Basic DATA-READ Program.

```
05 REM LISTING 5A
10 DIM X(2,3)
20 DIM Y(2,3)
30 FOR I=1 TO 2
40 FOR J= 1 TO 3
50 LET X(I,J)=0
60 LET Y(I,J)=0
70 NEXT J
80 NEXT I
90 READ A,B,C
100 IF A=-1 THEN 180
110 IF A=1 THEN 150
120 LET X(1,B)=X(1,B)+1
130 LET X(2,C)=X(2,C)+1
140 GOTO 90
150 LET Y(1,B)=Y(1,B)+1
160 LET Y(2,C)=Y(2,C)+1
170 GOTO 90
180 FOR I=1 TO 2
190 FOR J=1 TO 3
200 PRINT X(I,J),Y(I,J)
210 NEXT J
220 NEXT I
900 DATA 0,1,2
901 DATA 1,2,3
902 DATA -1,0,0
```



Listing 5B is a counting routine program equivalent to listing 5A using double-subscripted/multi-dimensional array. The array diagram is shown in Figure 3. A running total of like data values are entered and counted in the array addresses as shown in the Figure 3 matrix. Each data-set consists of three data values (A,B,C), two separating commas and a closing semi-colon. Thus in the data string (line 2) there are 2 data-sets consisting of 6 string characters each for a total string length of 12 characters (6 X 2 = 12). The arrangement of data in the DATA STRING is as follows:

2 LET A$="A,B,C;A,B,C;A,B,C; etc"

Applying this method of simulating DATA-READ statements with the ZX81 should present no problem, provided the demonstration programs are followed line by line and the technique of string slicing is understood. The only major difficulty which may be encountered is in actually slicing the data from the string. For example, if a non-numeric character is included in data which is to be converted to a numeric expression, such as a comma, the program will not run. Of course in this case an error code will be displayed (C/xx) upon execution of the program. Sliced data can be checked for correctness,

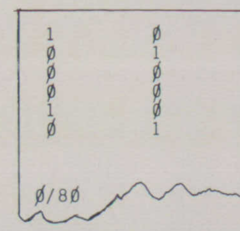
Listing 5B. ZX81 Simulation of DATA-READ Statement for Single-Subscripted/Multi-Dimensional Variable Array in Data Count Program.

```
1 REM LISTING 5B
2 LET A$="0,1,2;1,2,3;"
3 DIM X(2,3)
4 DIM Y(2,3)
5 FOR I=1 TO 2
6 FOR J=1 TO 3
7 LET X(I,J)=0
8 LET Y(I,J)=0
9 NEXT J
10 NEXT I
11 LET D=0
12 LET L=1
13 FOR N=1 TO LEN A$/6
15 LET S=VAL A$(L)
17 FOR J=1 TO 2
19 LET C=VAL A$(L+D+2)
21 IF S=1 THEN GOTO 27
23 LET X(J,C)=X(J,C)+1
25 GOTO 29
27 LET Y(J,C)=Y(J,C)+1
29 LET D=D+2
31 NEXT J
33 LET D=0
35 LET L=L+6
37 NEXT N
```

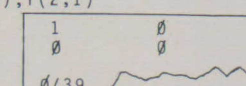
Note for 16K RAM: For 16K memory follow line 37 with lines 40 through 80. 1K memory will accept 16K program but memory will fill with a report 4/60 before the entire array is printed.

1K RAM: FOR 1K MEMORY ENTER EACH OF THE FOLLOWING LINE 39 ENTERIES IN SUCCESSION TO DISPLAY ALL MATRIX VALUES OF THE ARRAY:

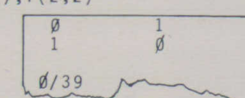
```
40 FOR I=1 TO 2
50 FOR J=1 TO 3
60 PRINT X(I,J),Y(I,J)
70 NEXT J
80 NEXT I
```



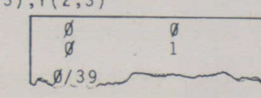

```
39 PRINT X(1,1),X(2,1),Y(1,1),Y(2,1)
RUN (ENTER)
```




```
39 (ENTER)
39 PRINT X(1,2),X(2,2),Y(1,2),Y(2,2)
RUN (ENTER)
```




```
39 (ENTER)
39 PRINT X(1,3),X(2,3),Y(1,3),Y(2,3)
RUN (ENTER)
```



Note: For 16K RAM all line numbers may be entered with addition of a trailing 0.

Figure 3. Array Diagram for Listing 5B.

	B=1	B=2	B=3	C=1	C=2	C=3
A=0	X(1,1)	X(1,2)	X(1,3)	X(2,1)	X(2,2)	X(2,3)
A=1	Y(1,1)	Y(1,2)	Y(1,3)	Y(2,1)	Y(2,2)	Y(2,3)

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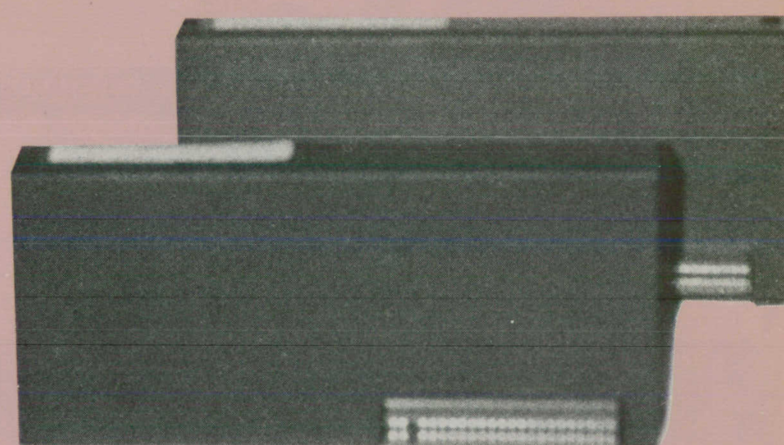

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however, by simply executing a print command which displays the sliced data prior to its use as a variable. The check is made during the writing of the program by entering a command to print the sliced data, running the program, checking the data for accuracy, deleting the data print command and then proceeding with the writing of the remainder of the program. For example, the following data slicing check could be used for program Listing 1B after writing line 50:

Step 1: Enter new line.
55 PRINT A$(X TO Y)
Step 2: Enter new line.
56 PRINT VAL A$(X TO Y)
Step 3: RUN program.
Step 4: Check displayed data for accuracy. Correct slice commands if necessary.
Step 5: Delete lines 55 and 56.
Step 6: Continue writing program.

Other Uses of This Technique

Use of the proposed ZX81 string statement technique is not limited to simulating DATA-READ statements. This method can be used equally well to simulate other Basic Language statements which cannot be executed directly on the ZX81 Computer.

Program Listing 6A shows a Basic program using an ON X GOTO N,N,N statement which cannot be executed on the ZX81.

Listing 6A. Conventional Basic ON X GOTO n,n,n, Program.

```
 05 REM LISTING 6A
 10 LET X=INT (RND*6)+1
 20 PRINT X;"#IS THE RANDOM NUMBER"
 30 PRINT
 40 ON X GOTO 100,200,300,400,500,600
100 PRINT "THE RANDOM NUMBER IS 1"
150 GOTO 700
200 PRINT "THE RANDOM NUMBER IS 2"
250 GOTO 700
300 PRINT "THE RANDOM NUMBER IS 3"
350 GOTO 700
400 PRINT "THE RANDOM NUMBER IS 4"
450 GOTO 700
500 PRINT "THE RANDOM NUMBER IS 5"
550 GOTO 700
600 PRINT "THE RANDOM NUMBER IS 6"
700 PRINT "END"
```

```
X IS THE RANDOM NUMBER
THE RANDOM NUMBER IS X
END
```

Listing 6B. ZX81 Simulation of ON X GOTO n,n,n Statement.

```
 05 REM LISTING 6B
 10 LET X=INT (RND*6)+1
 20 PRINT X;"#IS THE RANDOM NUMBER"
 30 PRINT
 40 LET A$="100,200,300,400,500,600,"
 50 LET L=1
 55 FOR N=1 TO LEN A$/4
 60 LET S=VAL A$(L TO L+2)
 65 PRINT "CYCLE NUMBER#";N
 70 IF N=X THEN GOTO S
 80 LET L=L+4
 90 NEXT N
100 PRINT "THE RANDOM NUMBER IS 1"
150 GOTO 700
200 PRINT "THE RANDOM NUMBER IS 2"
250 GOTO 700
300 PRINT "THE RANDOM NUMBER IS 3"
350 GOTO 700
400 PRINT "THE RANDOM NUMBER IS 4"
450 GOTO 700
500 PRINT "THE RANDOM NUMBER IS 5"
550 GOTO 700
600 PRINT "THE RANDOM NUMBER IS 6"
700 PRINT "END"
```

Note: To have program recycle enter the following lines:

```
710 PAUSE 125
720 CLS
730 GOTO 10
```

```
X IS THE RANDOM NUMBER
CYCLE NUMBER N
THE RANDOM NUMBER IS X
END
0/700
```

Listing 6B, however, shows the equivalent program structured for execution on the ZX81 using the same string statement technique previously described. The program generates a random number which is compared to the value of the first character of a data-set in the data string (line 40). When the string character value is read which equals the value of the random number, the remainder of the selected data set is also read to provide a GOTO line address. That line address then executes a print command which identifies the value of the random number. It should be noted that although Listing 6B is to demonstrate an ON X GOTO N,N statement, line 70 could execute any ZX81 command (PRINT, STOP, LET, etc).

It appears, then, that the ZX81 has lots of Basic capability if you can use your programming imagination and just keep $TRINGING ALONG WITH THE ZX81. ■

RUNning with Reduced RAM *Robert D. Hartung*

For most of us, the anticipation of being able to write extended programs when we first plugged in our new 16K RAM pack was soon somewhat tempered by the waiting out of the monotonous count at the end of every SAVE and LOAD. Also, functions such as CLS and NEW take much longer.

Without connecting and disconnecting the RAM pack, the advantages of a smaller RAM may easily be regained by changing the address of RAMTOP for any program which requires less than 3.1K RAM to RUN. Simply set RAMTOP below this limit by entering as direct commands (without line numbers) one of the following sets, with the 16K RAM plugged in:

```
For 1K (17408):     For 2K (18432)
  POKE 16388,0        POKE 16388,0
  POKE 16389,68       POKE 16389,72
  NEW                 NEW

For 3K (19710)
  POKE 16388, 254
  POKE 16389,76
  NEW
```

When you have set the RAMTOP address to 19710 (which was POKEd in as 76*256+254), your computor will behave as though it has only 3.1K RAM. (These addresses are valid only for 8K ROM). You can also LOAD programs into this 3.1K which have previously been SAVEd to tape in 16K, provided they do not exceed the RAM limit as it is now set. They may then be SAVE back to tape in 3K, saving time and wear and tear on your recorder—and your patience. The reduced RAM will remain in effect until the computor is powered-down or RAMTOP is reset.

If tape listing does not LOAD because it was SAVEd with strings or variables or DIMs defined in memory, it might fit into 3.1K if cleared before the SAVE to tape. Restore the 16K RAM by power-down and then LOAD the program. CLEAR and then SAVE it back to tape again in 16K. Reset RAMTOP to 19710 and try to LOAD it back. If you succeed, you may now SAVE it to tape in 3K RAM, but it will require 16K when it is LOADed back if you want to RUN it.

To keep track of the reduced number of bytes remaining during the listing of a

Robert D. Hartung, PO Box 125, Palmyra, NY 14522.

new program, first set RAMTOP to 19710 by POKE 16388,254 and ENTER; POKE 16389,76 and ENTER; and NEW and ENTER. Then enter these lines (with the 16K RAM pack in place):

```
1 DIM A(16)
2 FOR N=1 TO 16
3 INPUT A(N)
4 PRINT A(N);"###";
5 POKE 32751+N,A(N)
6 NEXT N
```

RUN and INPUT the following values, reading horizontally:

```
42  28  64  205  203  14
229  193  33  20  0  237
66  229  193  201
```

After checking the printout, add the following lines (changing line 1 to the USR command):

```
1 PRINT USR 32752;"#BYTES
  REMAINING"
7 STOP
8 SAVE "BYTES"
9 GOTO 2
```

SAVE to tape for future use with GOTO 8. After the SAVE, the display should show the table of INPUTs. Now delete all the lines except line 1 and RUN. The display should show 3101 BYTES REMAINING. The routine is resident above RAMTOP and will not be affected by RUN, CLEAR, NEW, SAVE, or LOAD as long as RAMTOP is not reset above 32752 or the computer is not powered-down.

RAMTOP must be set to 32752 or less before "BYTES" is LOADed back from tape, and the machine code values will then be automatically POKEd in when the LOAD is completed. (They are not SAVEd to tape as they exist above RAMTOP but are reproduced from the variables stored in DIM A(16). Line 1 will have to be reentered after the LOAD of a listing other than "BYTES" or may be used as a direct command (without a line number) at any time during the listing of a new program as long as the "BYTES" routine is resident above RAMTOP.

The actual bytes remaining will vary slightly from the number displayed but when used for most practical purposes, such as noting the effects of byte-saving techniques, the routine can be very helpful. RAMTOP must be set to 32752 address by POKE 16388,240 and ENTER, POKE 16389,127 and ENTER; NEW and ENTER for 16K.

Read This First

Before entering the programs in this issue, readers should note the following:

The **ROM** and **RAM** requirements for using a given program are shown at the top of the first page of the article. *Observe these carefully.*

NEWLINE and **ENTER** are used interchangeably.

A letter after a number shows the type: b for binary; d for decimal; h for hexadecimal.

In PRINT statements:

#: Enter a necessary space.

A (32): Use the graphic character on the A key 32 times. The underline means use the graphic on that key.

A: The overline means use the key in inverse.

INPUT: An underlined *word* found on the keyboard should be entered from the keyboard, not spelled out. If the keyword will not ENTER, hit THEN, the keyword you want, backspace and delete THEN, continue entering the line. This memory saving technique may be disregarded if you have enough RAM.

The Votem *Lawrence A. Kelly*

Votem. Kit: $39.95; assembled and tested: $59.95; plus $3 s&h. Down East Computers, PO Box 3096, Greenville, NC 27834.

The Votem, to play on James J. Carr's book *Digital Interfacing to an Analog World* (Tab Books, Summit, PA. 1978), is an analog interface to Sinclair's digital world.

Analog/Digital Conversion

Analog (related to analogous) refers to relationships by ratios. The analog device relates numbers to a turn on a wheel such as our rapidly disappearing analog wrist-watch; to the movement of a rod or shaft such as the slide rule; or to continuously changing voltages or currents such as in an electronic analog computer.

The electronic digital computer, of course, also works on voltages but in discrete packages or digits as in the digital wrist-watch with the liquid crystalline display. Digital computers, unlike the watches, do not count in decimal (0-9) in their digits, but rather use a bistable digit which is voltage or no voltage, in other words, on or off, 1 or 0, true or false.

What Carr is driving at in the title of his book is that most of the devices we use to measure and control things are analog in nature. Transducers convert physical energy such as strain, thermal energy, or light energy into electrical energy in a continuously changing voltage or current related to the amount of energy, yes, its analog. In order to control things, voltages or currents have to be output.

The Votem is a device which can measure external events relating Analog/Digital (A/D), but it does not go the other way for control, Digital/Analog (D/A).

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A/D by the Votem

How does the Votem manage the marriage between the analog and digital worlds? It takes advantage of the fact that the Z80 processor uses a crystal to generate a pulse at a given frequency. This produces a clock to take care of the timing of events in the operating cycle of the machine.

The heart of the Votem is a voltage to frequency converter (V/F, AD537JH). The V/F relates the frequency of the Sinclair clock to voltage applied to the external connection of the Votem. This is done via a machine language program (provided in the manual) which converts the clock pulses to a count/volt. Basic programs can then convert the voltage to something meaningful such as the temperature at the end of the probe and display it periodically on the TV screen.

Temperature Measurement

The Votem comes with a temperature probe of the resistance type with the change in resistance proportional to temperature. By calibrating this probe to 0 C (ice) and 100 C (boiling water) one can display on the screen the room temperature using a Basic program. The calibration is all important in the final accuracy of the result because the software uses these calibration factors in the calculations. Since clock frequencies can vary from computer to computer, accuracy is to a certain extent in the hands of the user.

The Votem can interface with positional devices (e.g., joysticks), photocells (e.g., spectrophotometers), and virtually anything with an output voltage in the 0-1V range (e.g., ionization detectors).

Tape Load Circuit (Earphone)

The Votem connects via the tape earphone port and thereby leaves the expansion port of the computer free. A RAM pack or Byte-Back's BB1 control module, or both can still be used. The BB1 device can be programmed to turn on relays which can switch on 110VAC items such as lights or coffee makers. The ZX/TS owner has an opportunity to do some practical things not previously possible.

Getting the most mileage possible out of the device, the frugal designer also employed unused portions of the circuitry to condition the tape signal to improve LOADing, providing audio output of the signal and an LED which glows during the LOAD. We found this feature to be quite useful. Those with LOADing problems might find the the Votem a useful addition for this reason only.

With just three integrated circuits—only one of which is in a DIP, it is a relatively easy kit to assemble, for those who like to become intimately involved.

For those who want to make the most out of a Votem/Sinclair combination Carr's book is recommended reading.

The Votem is probably not for those who cannot quite remember who Ohm was, or which parameter goes on top and bottom in his equation. But for those who do and would like to expand the cognitive horizons of their computers the Votem is a must.

Lawrence A. Kelly, Ph.D., 28 Countrywood Dr., Morris Plains, NJ 07950.

Timex Developments *Paul Grosjean*

The printer is out. Three new machines are about to hit the market. Another price reduction is made. These are among the recent developments in the Timex Sinclair computer field.

Timex Sinclair 1000 for $49.95

In our last issue we reported that Timex Computer Corporation had reduced the suggested retail price for the TS1000 to $69.95. On April 28, 1983, Timex announced a further reduction to $49.95. Remember the breakthrough of the original ZX80 for $199.95?

Timex Sinclair 1500 for $79.95

On May 17 Timex announced the introduction of the Timex Sinclair 1500, an enhanced version of the TS1000. Shipment is expected to begin in July.

The most obvious enhancement is a new styled case supporting a full movement keyboard instead of the familiar membrane keyboard. The 40 keys have the same layout, commands, functions, graphics, and characters as the TS1000. The second major enhancement is that the onboard RAM has been increased to 16K and can be expanded to 32K by the TS1016 16K RAM pack.

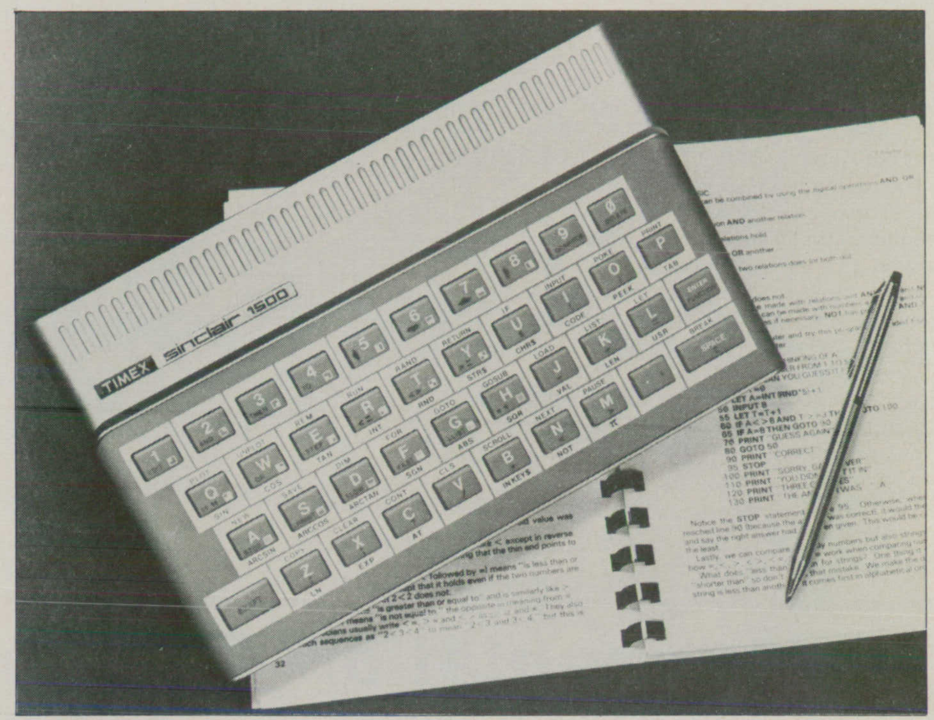


Photo 1. The Timex Sinclair 1500.

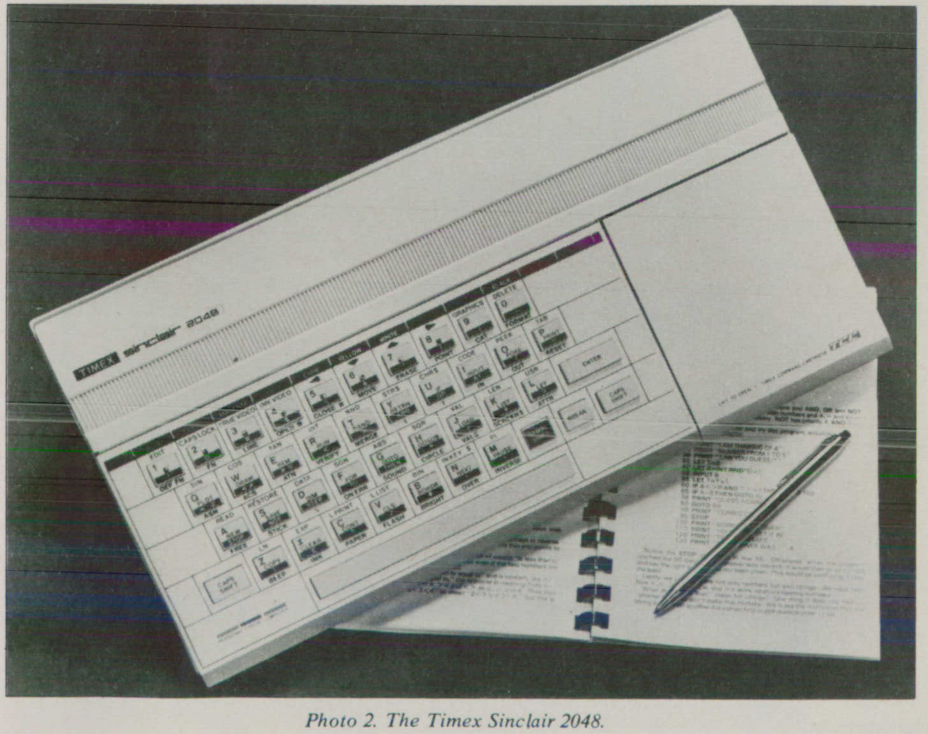


Photo 2. The Timex Sinclair 2048.

The TS1500 is compatible with all TS1000 peripherals and software. Standard cassette recorders are used for saving and loading, but the new instant-load software cartridges being developed by Timex will plug directly into the computer. These palm-sized cartridges are expected to cost from $12.95 to $29.95 and to be available in August.

Timex Sinclair 2000 Series

Timex also announced on May 17 that two computers in the 2000 series would be available to retailers in August. One with 72K RAM is priced at $199.95; the other with 40K RAM at $149.95. The video display can be output to most color and black-and-white TV sets as well as to a monitor.

The keyboard has 40 moveable keys arranged in typewriter format with upper and lower case letters, repeat key option for all keys, 16 built-in graphics characters, and 21 user-programmable graphics characters. Each key performs up to six functions. Most of the functions, com-

Continued on page 80.

Memopak High Resolution Graphics Module

John Herriott

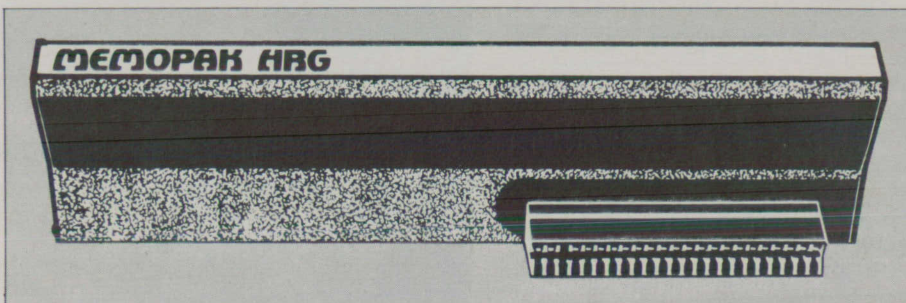
Memopak HRG Module. $99.95 plus $4.95 s&h. From Memotech Corp., 7550 W. Yale Ave., Denver, CO 80227.

The Memopak High Resolution Graphics Module, in dull black matching the computer, fits in between the Memopak parallel printer interface and the 64K memory module. Velcro tape or double sided adhesive tape comes with each unit to ensure a wobble-free set-up.

The 18 page instruction booklet, which serves only to whet the appetite, begins with a brief but lucid account of a "video page," how to set the switches and remove the small jumper switch for full use of the 64K.

John Herriott, 143 LeMarchant Rd., St. John's, Nfld, Canada A1C 2H3.

A short program illustrates setting parameter V and calling a routine contained in the 2K EPROM. The result is a black



screen with white-lettered MEMOTECH. The small black button on the right side returns the computer to Basic.

Armed with this experience, one can follow the explanation of how the HRG works, the nature of a pixel, a "video page," and the bit and byte summaries.

Thirty subroutines can be called from address 8192. There are five varieties of routines: Page: manipulation and preparation of displays. Block: rolling and scrolling the display in four directions. Character: sketching, unsketching, inverse-sketching of user-defined characters. SINCH: plots ZX81-defined characters. Line routines draw and wipe out lines and fill in areas of your masterpieces. PLOT and UNPLOT function as on the ZX81 except that the result is a tiny spot instead of a big, square blob. 47616 of these spots or pixels are possible; 192 vertical and 248 horizontal.

SKETCH allows you to design your own characters by setting each bit:

LET C$="10101:"

gives you a line. The * can be used instead of 0 for the sake of clarity. By astute use of the NESW direction commands one can produce a neat cross, thus:

LET C$="1***1NE1*1NE1NW1*1NW1* **1:"

My efforts to produce a Russian character set (well, one letter actually) developed an interesting array of Devenagri and Coptic symbols at first!

Listing 1.

```
  5 REM "L/BOX"
 10 LET V=40000
 20 LETZ$="STARCH"
 30 RAND USR 8192
 35 LET Z$="PLOT"
 40 FOR I=1 TO 50
 50 LET X =10
 55 LETY=20+I
 58 REM VERTICAL/L
 60 GOSUB 9990
 63 REM LOW/DIAG
 65 LET X=10+I
 70 LET Y=20+I/2
 75 GOSUB 9990
 77 REM HI/DIAG
 80 LET X=10+I
 85 LET Y=70+I/2
 90 GOSUB 9990
 92 REM MID/VERT
 95 LET X=60
100 LET Y=45+I
105 GOSUB 9990
108 REM LOW/HORIZ
110 LET X=10+I
115 LET Y=20
120 GOSUB 9990
122 REM MID/HORIZ
125 LET X=60+I
130 LET Y=45
135 GOSUB 9990
137 REM HI/HORIZ
140 LET X=60+I
145 LET Y=95
150 GOSUB 9990
153 REM DIAG/R
160 LET X=60+I
165 LET Y=20+I/2
170 GOSUB 9990
175 LET X=110
180 LET Y=45+I
185 GOSUB 9990
220 LET X=60+I
225 LET Y=45+I
230 GOSUB 9990
500 NEXT I
9990 RAND USR 8192
9995 RETURN
```

Line notes:

20: Macro page command; combines Start, Clear, HRG.

60: The call is assigned to a subroutine.

Listing 1 uses PLOT to produce a representation of a portion of a box with each line being drawn simultaneously. Although the program might appear unwieldy because of the GOSUBS, one can watch each of the lines add its bit in the proper order. Adding line 37 FAST reduces the time the program takes from 65 seconds to 13, but the joy of watching the process is lost! Any use of FAST mode should be countermanded with a SLOW. The instructions say that one can break into a program in FAST mode by entering SLOW and then pressing the Basic RETURN button. However, I have had no success with this, and so I take the obvious precaution.

"LAUNCH", one of the line routines, fires black lines up the screen. A neat routine to change the firing position holds all kinds of game possibilities.

"Draw It" by Robert Boynton (*SYNC* 2:4) or "Draw and Store" by James J. Hollandsworth (*SYNC* 2:6) can be suitably modifed to produce a fairly fine-line sketch-pad.

With the ability to pack pages of graphics into a Basic string which can be SAVEd and unpacked later for display, the Memopak HRG is a useful addition to a ZX/TS set up.

Timex Developments, continued...

mands, characters of the TS1000 are retained and in the same places, but a few have been moved, e.g., the number keys have the same character placement as the standard typewriter keyboards. New functions have been added to handle the increased capabilities of the computer. The Basic has also been expanded, most notably with READ, DATA, and RESTORE.

Probably the chief difference from the 1000 that users have been anticipating is the high resolution color capability. The features include eight colors; control of the foreground, background, and border areas; a flash command; and a brightness control. The display area consists of 24 lines with up to 64 characters each. The high resolution display has 256 dots horizontally and 192 vertically which can be individually addressed.

A fully programmable sound capability is provided by a built-in speaker with a range of 10 octaves and 130 semitones. The BEEP command allows setting the pitch and duration of sounds. Users who want to compose music will be able to do so on the computer.

Although the 2000 series continues to use cassette saving and loading, an extensive software line will also be available on the new mini-cartridges that plug directly into the computer. Another feature is a built-in real time clock. This will allow the user to run real time programs and coordinate with appliances.

Directory of Suppliers

Ed.—This Directory supplements the list in our Buyer's Guide Issue. A few suppliers are repeated because of the products carried over or new product listings.

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2352 S. Commerce
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just for fun

Generally *SYNC* prefers articles in some depth to help you get more out of your computer. However, we receive many short programs that illustrate a point, demonstrate a technique, or show something the reader has found interesting. "Just for Fun" shares these programs with you. If you learn something, great. If you have some fun, great. If you have some that you want to share, send them to: Just for Fun, SYNC, 39 E. Hanover Ave., Morris Plains, NJ 07950.

Horizontal Bar Graph

Michael W. Schultz

Type in the program. Then with your computer in either FAST or SLOW mode, hit RUN and ENTER. As the prompts appear, enter the starting year of your graph, the number of bars you wish to compare, and the interval between years (e.g., 1, 5, 10). When the words "HORIZONTAL BAR GRAPH" appear on the screen, begin entering the data, one number at a time. Each value must be below 51 so scale your data accordingly if you are INPUTting larger numbers. The first year entered will be shown

Michael W. Schultz, 3650 Mossvale Dr. 20-D, Mobile, AL 36608.

```
  10 REM "HORIZONTAL BAR GRAPH"
  20 PRINT "ENTER YEAR TO START
GRAPH"
  30 INPUT D
  40 PRINT
  50 PRINT "ENTER NUMBER OF BARS
 DESIRED"
  60 INPUT N
  70 PRINT
  80 PRINT "ENTER INTERVAL BETWE
EN YEARS"
  90 INPUT A
 110 SCROLL
 120 PRINT TAB 5;"HORIZONTAL BAR
 GRPH"
 130 FOR I=1 TO N
 140 SCROLL
 150 INPUT Z
 160 PRINT D
 170 FOR X=8 TO Z+8
 180 PLOT X,0
 190 NEXT X
 200 PRINT Z
 210 LET D=D+A
 220 NEXT I
```

with its bar graph and the exact data number. As each following year is shown, the display will be SCROLLed up the screen; after about twenty bars the display will start disappearing off the top of the screen.

This program is designed to be flexible in structure so the user can easily edit it to meet his individual needs, such as personal finances, business applications, and so on. This can be done by simply changing the prompts in lines 20 and 80.

Bar graphs, either vertical or horizontal, are very useful as visual aids in comparing statistical values. Vertical graphs are more

Continued on page 114.

Machine Code and Your TV Screen *Harry Doakes*

One of the ways that Basic is slow is in putting things on the screen. Have you ever played a game in Basic and you wanted things to zip across the screen, but, instead, they crawled? It is frustrating, but Basic is simply very slow in this department. In the 8K Basic SLOW mode, even something as simple as

```
10 FOR A=1 TO 10
20 PRINT A
30 NEXT A
```

takes a long time. (Try it and you will see.)

You can speed up the process of putting something on the screen by using machine code, but, to do that, you must have some understanding of how the computer puts things on the TV. This is a little technical, but do not panic—it will not last long.

TV Guide

Somewhere in RAM there is a block of memory called the *display file.* This is where the computer stores what will go on your TV screen. Depending on how long your program is, the display file could be almost anywhere in memory. For example, when there is no program in the computer, the display file starts at location 16509—near the bottom of RAM. With a 16K RAM pack and a long program, the display file might start way up around memory location 32000—almost at the top of memory.

To put something on the TV screen, the computer has to know where the display file starts. It keeps track of that starting point as one of the "system variables." The people at Sinclair call this particular system variable "D-FILE" (for "display file"), and it is at the same place for 4K and 8K Basic—memory locations 16396 and 16397.

Any time you want to know where the display file begins, just look at those two memory locations. In Basic, you can do it like this:

```
PRINT PEEK (16396)+256*PEEK
(16397)
```

Notice that you must multiply what is in the second memory location by 256, and add it to what is in the first memory location. This is similar to the way you load a number into a register pair in machine code—first comes the *remainder*, then comes the *quotient.*

Short and Sweet

One other thing you need to know about the display file is that it is only as long as it needs to be. The display file takes up space that otherwise could be used by a Basic program or by variables. Since some Sinclair computers come with only a small amount of RAM, it is important to use memory efficiently—and that means keeping the display file short.

In the display file, each line of the TV screen shows up as a string of character codes (numbers between 0 and 63, or between 128 and 191 for reversed characters—white on a black background). The last character code in each line is an ENTER code, 118. (The complete list of character codes is in the appendix to your manual titled "The Character Set.")

If a line on the TV screen is empty, then the only thing in that line will be the ENTER code. This is about as short as you can get.

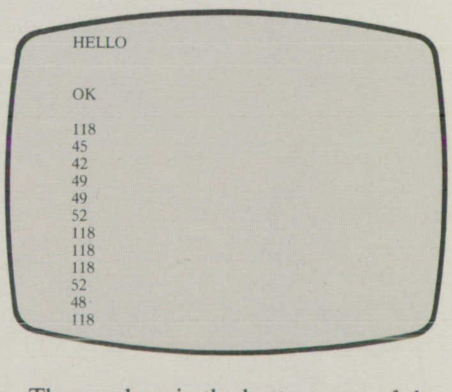
Taking a Look

Let's take a look at the display file. Type in and run the program in Figure 1.

Figure 1.

```
10 PRINT "HELLO"
20 PRINT
30 PRINT
40 PRINT "OK"
50 PRINT
60 FOR A=0 TO 12
70 LET DFILE=PEEK (16396)+256*
PEEK (16397)
80 PRINT PEEK (DFILE+A)
90 NEXT A
```

Your screen should look like this:



The numbers in the bottom part of the screen are the first 13 numbers in the display file. If you check them against the appendix of your manual, you will find that they match up exactly to the first dozen characters on the screen, including the ENTER code at the end of each line.

But notice: the *first* byte in the display file is always an ENTER code.

Harry Doakes, PO Box 10860, Chicago, IL 60610

Quick-change Artist

When something is added to a line in the display, everything in the display file has to move—shifting down one position to make room. That takes time, and it can get pretty complicated. The easiest way to get something on the screen is to *start out* with something there, then change it.

For example, try running the Basic program in Figure 2.

Figure 2.

```
10 PRINT "X"
20 LET DFILE=0
30 FOR A=0 TO 63
40 LET DFILE=PEEK (16396)+256*
PEEK (16397)
50 POKE DFILE+1,A
60 NEXT A
```

(Line 20 is necessary only for running the program in 4K Basic, in which the value of "D-FILE" changes every time you create a new variable.)

If your computer can run in SLOW mode, you will see the character in the upper left-hand corner of your screen change quickly, running through the regular character set.

It runs pretty quickly, but, as you would probably guess, it runs much, *much* faster in machine code. How can we translate this routine into machine code form?

The first thing we have to do is rewrite the "FOR/NEXT" loop into a simpler form. Remember, Z80 machine code has nothing exactly like FOR and NEXT. The results are shown in Figure 3.

Now we have solved the problem of the loop; we can use load, increment, and jump instructions to replace lines 20, 40, and 50.

But we will also need to use two new kinds of load instructions—instructions that will work the way PEEK and POKE work in Basic.

To do a machine code PEEK at location 16396, use this instruction:

LD A,(16396)

The equivalent in Basic is

LET A=PEEK (16396)

However, you can use this instruction only to load register A.

Remember, there is a big difference between

LD A,5

and

LD A,(5)

The first one puts the number 5 in register A. The second one puts whatever number is in memory location 5 into register A. This is the difference between

LET A=5

and

LET A=PEEK (5)

The number in parentheses is sometimes called a *pointer*, and that is a good way to remember how it works. It points to where the computer will find the number it is going to load.

As you might expect, the machine code version of POKE uses the same kind of pointer notation. The instruction

LD (16396),A

works like

POKE 16396,A

The number in register A goes into memory location 16396.

Again, you can use this instruction only to load register A.

Figure 3.

```
10 PRINT "X"
20 LET DFILE=0
30 LET A=0
40 LET DFILE=PEEK (16396)+256*
PEEK (16397)
50 POKE DFILE+1,A
60 LET A=A+1
70 IF A<64 THEN GOTO 30
```

Doing the Two-step

You can also do a machine code PEEK or POKE with the register pairs BC, DE, and HL. One way is to load each register individually. For example,

LD A,(16396)
LD L,A
LD A,(16397)
LD H,A

would load the system variable "D-FILE" into register pair HL.

But you can do the same thing with a single instruction:

LD HL,(16396)

This automatically loads the number at location 16396 into register L, and loads the number at location 16397 into register H. It does two steps at once. This is faster for the Z80 processor, and easier for you.

You can also use this instruction with the other two register pairs, BC and DE. And you have probably guessed already that, if you can PEEK with any register pair, you can simply reverse the process to do the machine code equivalent of a POKE. You are right—

LD (16396),HL

is equivalent in Basic to

POKE 16396,L
POKE 16397,H

Pointers by the Pair

So far, we have covered the ways that you can PEEK or POKE to a specific numbered location. The number in parentheses in the machine code instruction always points to the memory location that is involved.

But in Basic, you can also use PEEK and POKE with variables, e.g., commands such as

LET A=PEEK (HL)

or

POKE HL,A

Can you put parentheses around the name of a register in machine code, and use it as a pointer?

Yes, but only *sometimes*.

A memory location is a number between 0 and 65535. That means it will take *two* registers—a register pair—to handle the number. As a result, you cannot say

LD A,(B)

but you can say

LD A,(BC)

In addition, register pairs BC and DE can be used only to PEEK or POKE with register A. Remember, register A is special. It is the register you can add to or subtract from, and it has many of its own special instructions we have not seen yet.

Here are the *only* machine code PEEK and POKE instructions that use register pairs BC and DE:

LD A,(BC)
LD A,(DE)
LD (BC),A
LD (DE),A

That is not much, certainly. What about register pair HL?

Pay close attention here—this is important:

In almost any instruction in which you can use one of the seven regular registers—A, B, C, D, E, H, and L—you can also use register pair HL as a pointer.

Here are a few examples:

LD B,(HL)
LD (HL),E
ADD A, (HL)
CP (HL)

If you stop to think about it, you will realize that is pretty impressive. This means you can use almost any memory location just like a register, so long as register pair HL is pointing to that memory location.

Whew

By now you are probably ready for a rest. But we are so close to being done with the machine code version of our quick-changing number program, so let's finish it up fast. Figure 4 shows the program so far.

Figure 4.

```
 10 PRINT "X"
 20 LET DFILE=0
 30 LET A=0
 40 LET DFILE=PEEK (16396)+256*
PEEK (16397)
 50 POKE DFILE+1,A
 60 LET A=A+1
 70 IF A<64 THEN GOTO 30
```

If we use register A for A and register pair HL for DFILE, we can translate it just about line by line. Starting with line 30, Figure 5 shows what we have so far.

Figure 5.

```
        LD A,0          62,0,
        LD HL,(16396)   42,12,64,
        INC HL          35,
LOOP:   LD (HL),A       119,
        INC A           60,
        CP 64           254,64,
        JR C,-6         56,-6,
        RET             201
```

Figure 6.

```
 10 LET Q=17390
 20 FOR A=0 TO 12
 30 PRINT A;"########";
 40 INPUT B
 50 POKE A+Q,B
 60 PRINT PEEK (A+Q),
 70 NEXT A
 80 CLS
 90 PRINT "X"
100 LET B=USR (Q)
```

Figure 7.

```
 10 PRINT "00000000000000000000
"
 20 LET DE=PEEK (16396)+256*PEE
K (16397)
 30 LET DE=DE+20
 40 LET HL=DE
 50 LET A=PEEK (HL)
 60 LET A=A+1
 70 IF A<38 THEN GOTO 110
 80 POKE HL,28
 90 LET HL=HL-1
100 GOTO 50
110 POKE HL,A
120 GOTO 30
```

Now let's poke this routine in and run it using the loader program in Figure 6. (Notice that PRINT "X" is part of the Basic program.)

First reserve space at the top of memory like this:

4K ROM: Type

PRINT USR(620)

Wait until the screen clears. Then type again

PRINT USR(620)

8K ROM: Enter this program:

10 POKE 16388,-20
20 POKE 16389,PEEK 16389-1
30 NEW

The program in Figure 6 is designed for a ZX80 or ZX81 with 1K of RAM. For a 2K TS1000, change line 10 to

10 LET Q=18414

If you are using a 16K RAM pack, change line 10 to

10 LET Q=32750

Now, for either ROM, type in the program in Figure 6.

Run the program and enter the numbers in the right-hand column of Figure 5 in exactly the order they appear.

Now you will see the character change even faster than the TV changes the screen—you may find it hard to believe anything happened at all. That is *fast*.

Doing It Yourself

You can also use the PEEK function to find out what is in a particular location on the screen. Figure 7 gives a short program that turns your display into a counter.

Can you work out the machine code program that will do the same thing? If you try running it, watch out—the lowest digits will probably flash by so fast, you will not be able to see them at all.

Variables—in Machine Code?

Now we know how to move a number between a memory location and a register. We can move the number from a register to a memory location (like the POKE command in Basic), or move it from the memory location to a register (like the PEEK function in Basic).

Besides looking at and putting things on the TV screen, there is something else we can use the machine code PEEK and POKE for—something even more useful and important. With these instructions, we can create our own machine code program variables—as many of them as we like.

Here is how it works:

Suppose we designate a specific byte of memory as a variable. (The best way is to choose a byte of memory that is near the machine code program. That way, it will be in protected memory, and will not be accidentally changed by the Basic system.) We can store a number at that

With variables, it is easier than ever to translate a program from Basic to machine code.

memory location, and put the number into a register only when we need it.

For example, if we have a variable at location 17000, we can add 5 to it with these instructions:

```
LD A,(17000)
ADD A,5
LD (17000),A
```

A one-byte variable can hold any number from 0 to 255. To hold a larger number, we can use a variable that takes up two bytes. It can hold any number from 0 to 65535. We could add 5 to that kind of variable like this:

```
LD HL,(17000)
LD DE,5
ADD HL,DE
LD (17000),HL
```

Think for a moment about what this means. Up till now, we have only had a few registers to work with. As a result, we could keep track of only a few numbers at once—one number in each register. But by using variables in our machine code programs, we can keep track of many different numbers. There is really no limit to the number of variables we can use in a machine code program except the amount of available memory.

However, we must keep in mind that using variables takes more instructions than keeping all the numbers in registers. It also makes your machine code programs run a bit slower since it takes time to get variables from memory and load them into registers, and then to move them back from registers into memory after you are finished working with them.

It takes time—but not much time. For example, on your computer it takes an extra *8 one-millionths of a second* to get a one-byte variable and then put it back.

That kind of time, we can usually afford.

Figure 8.

```
LD A,(17002)     get R
LD B,A
LD A,(17003)     get S
ADD A,B          add them
LD (17001),A     put result in Q
```

There is a big advantage to using variables, though, that really makes it worthwhile. With variables, it is easier than ever to translate a program from Basic to machine code. A few more instructions are required than before, but with variables you can translate lines of Basic more directly.

Up until now, for example, we have had trouble with a line like

LET Q=R+S

First we had to break it down to

LET Q=R
LET Q=Q+S

and then decide what registers to put the numbers Q, R, and S in.

But with variables we can translate the single line of Basic into a series of machine code instructions. If Q is the variable at memory location 17001, R is at 17002, and S is at 17003, then

LET Q=R+S

becomes as in Figure 8.

Get the idea? It may seem a little more complicated, but here is the key: you can always use exactly the same routine to add two variables together and put the result in a third variable. To do the same thing with three different variables, all you have to do is plug different variable locations into this same set of instructions.

Remember that machine code has no

error messages, and a mistake will probably make your computer crash. Then you have to unplug the computer and start all over again from scratch. Keeping track of what you are doing on paper or tape may save redoing a lot of work.

The more you can use "standard" chunks of program—like this routine for adding two variables together, the easier it is to write machine code routines that will not crash.

What is more, in Basic, you *do* have error messages, and, if there is a mistake in your program, it usually means you have to change just a line to fix the problem, then run it again. One easy way to write a machine code program is to start out by writing the program in Basic, making sure it runs properly, then translating the program into machine code, to get all the advantages of machine code speed.

It may not quite be all the best of both worlds, but it comes a little closer.

Coming Attractions

There is another big advantage to using variables in our machine code programs: it makes it easy to send a number into a machine code routine.

We already know how to get an answer out of a machine code program. When the machine code routine hits the "return" instruction, the value in one of the register pairs will be returned to Basic. This is the HL pair on the 4K ROM, or the BC pair on the 8K ROM.

But suppose we have a machine code routine that can draw a line on the screen from one point to another. How can we tell the routine what two points to draw the line between?

If we have made the coordinates of the two points variables in our machine code routine, it is easy. Since we know the memory locations of the variables, we can POKE our coordinates into the variables from our Basic program, before it reaches the line where the USR function sets the computer to work on the machine language routine.

We can also get as many answers as we like from a machine code routine, by PEEKing at the variable locations after the computer has returned to Basic. Usually we will not need to do that, but it is nice to know we can.

Next time, we will look at a machine code line-drawing routine that is not only much faster than Basic, but much smaller, too. The Basic version barely fits in a computer with 2K RAM, while the machine code takes up less than 300 bytes.

If you have comments or questions about machine code programming, or if something is not quite clear, let me hear from you. Be sure to send along a stamped, self-addressed envelope if you need a reply. ■

Adding a Counter in Hardware *Bernard Puerzer*

Sure, we all know computers are smart, but can they tell time? Not without some work.

Since getting my computer, I have been interested in configuring it to send and receive Morse code and display it on the screen. The first problem, discussed in my article "Machine Code Keyboard Scanning" (*SYNC* 1:4), was to figure out how to read the MicroAce/Sinclair keyboard. This is needed for the transmit portion of this task. Next I added 16K RAM to hold the program and Morse Code message buffers.

I was now ready to take up the next problem: I needed to know how long the Morse Code key is held down to determine if it is a dot or a dash. I also needed

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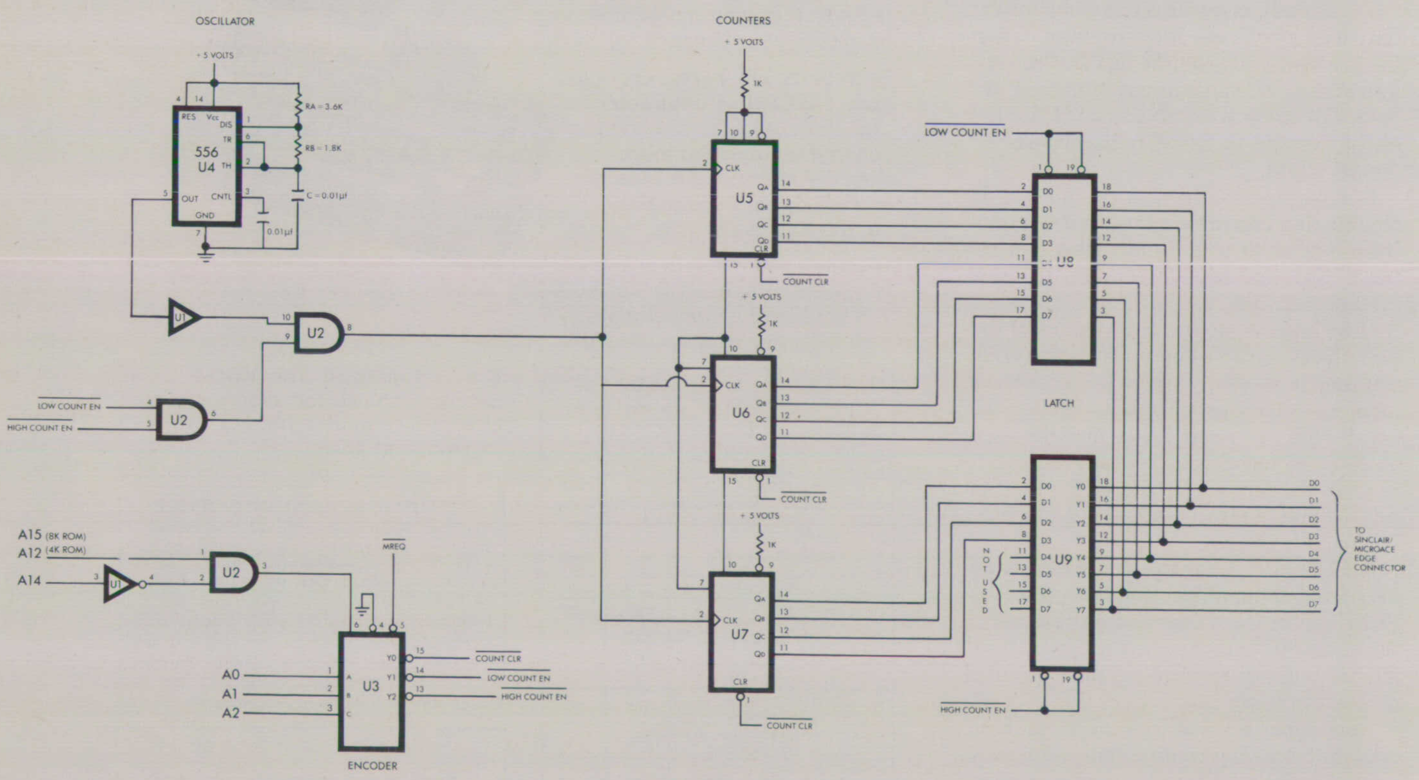
Figure 1. Counter Circuit Schematic.



Parts List.

PART #		RADIO SHACK#
U1 =	74LS14	
U2 =	74LS08	276-1822
U3 =	74LS138	276-1939
U4 =	556 TIMER	276-1728
U5-7 =	74LS161	
U8-9 =	747LS244	276-1941

THE 74LS14 and 74LS161 are available at most electronics parts stores.

to know how long the Code Key is up to determine if the last character received is the last character of the word or not. If it is, I need to display a space before the next word.

So I needed a timer to tell the time between one event and the next. I did not want to add hardware if the same job could be done through programming because my list of test equipment includes an analog voltmeter and that is it. Troubleshooting a program seems somewhat easier to me than troubleshooting microprocessor hardware.

But, in this case, there is no way around adding hardware if I wanted an accurate counter. The MicroAce/Sinclair has a memory location that is incremented 60 times per second if a display is on the screen, but I could not be sure there would always be a display. Besides, it increments every 16.7 Msec, which is too slow for my application. So I needed a timer in hardware. Such a timer that can run while the computer is doing something else can be a benefit in many other applications as well.

Design

There are several ways to add a hardware timer to the MicroAce/Sinclair.

My first attempt was to use a Z80 Counter Timer Chip (CTC). This really quite marvelous device allows the user to program any of 4 channels to be either a counter or a timer, with an interrupt generated when the counter reaches zero. I spent many frustrating evenings designing and constructing a circuit using the CTC chip but to no avail. I just could not get the MicroAce to program the chip. At this point I was convinced that the CTC chip that I had was bad.

So I had to decide whether I wanted to purchase another one ($6-15 depending on where you order it and how long you want to wait for it) or to come up with another design. The challenge of a new, simpler design (also a flat wallet) won out.

So I proceeded to develop a design using 74LS161 counters (cheap and easy to acquire). First I had to determine the smallest and largest time intervals needed. For my application I needed intervals between 0.1 Msec and 100 Msec. This would allow me to transmit and receive Morse Code at about 3 to 30 words per minute.

Then I designed an oscillator that would put out pulses of 50μsec (one-half the smallest time that I need). This oscillator would feed a counter comprised of three 74LS161 counters which give me 12 bits output (4 bits per counter). This allows the counter to count from 0 to 4095. Since I am counting 50 μsec intervals I have the ability to count from 50 μ sec to 204.8 Msec (4096 x 50 μsec). This

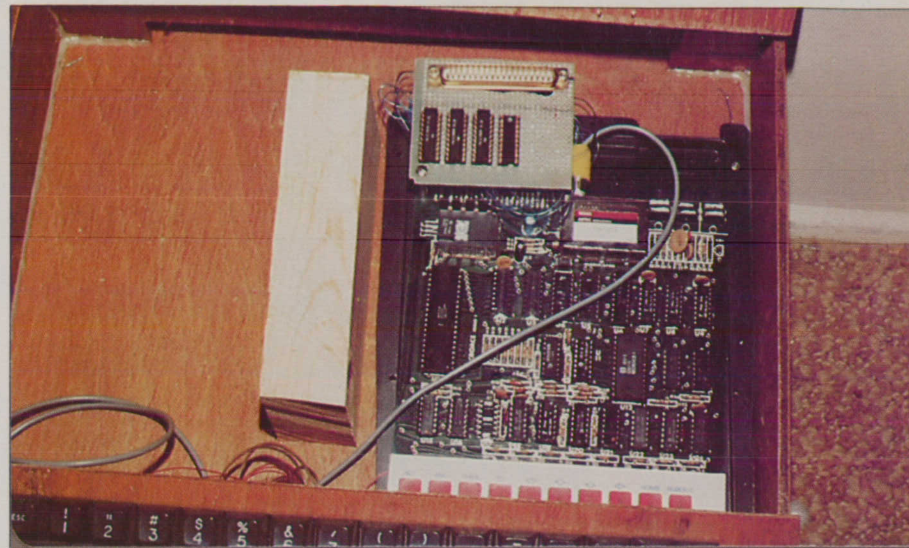


Figure 7. Buffer board (see Figure 4).

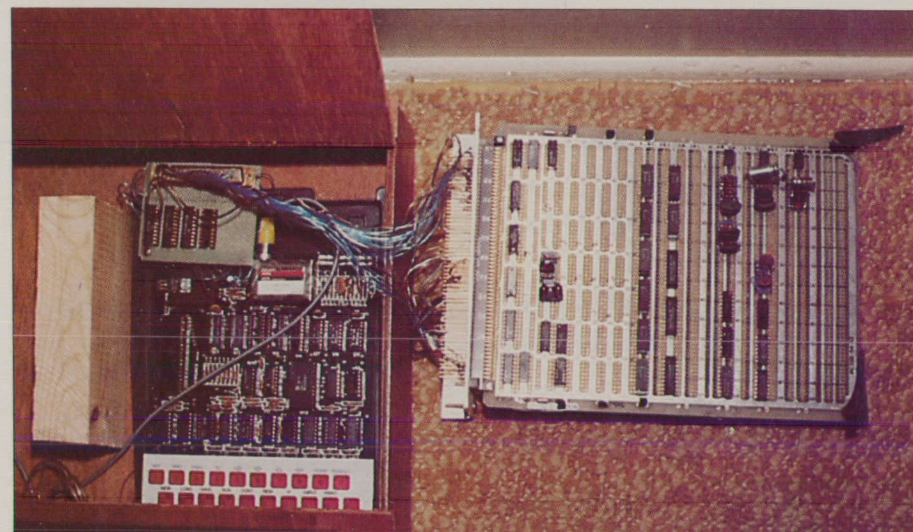


Figure 8. Prototype board (16K RAM and counters) connected to buffer board.

Figure 9. Prototype board in place.

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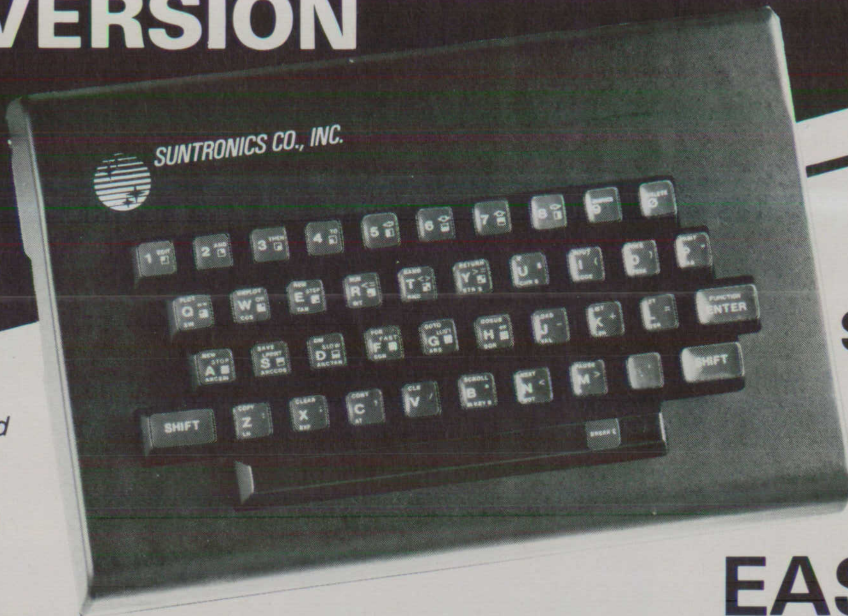

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is twice the time I need to measure, and so more than adequate for the job. More of these counters can easily be added to obtain any number of counts needed.

The oscillator uses a 556 Timer chip that I had in my parts box. This chip is a dual 555 timer, but I am using only one of the timers. The 555 or 556 chip is readily available. A 555 chip can be used, but be careful because the pin-out is different from the 556 pin-out shown in the schematic (Figure 1). Since I am using this chip as a free-running oscillator, I chose the values of RA, RB, and C to cause an oscillation of 20 Khz (50 μ sec).

If you want your counter to count at a different time interval, use the following formula to determine the RA, RB, and C values:

$$F = \frac{1}{T}$$

$$F(\text{Frequency}) = \frac{1}{T}(\text{time interval}) = \frac{1.44}{(RA + 2RB) \times C}$$

When choosing RA and RB, you must also be aware of the duty cycle—the ratio of the time the waveform is low (or high) to the time it is high (or low). The following formula determines the duty cycle:

$$D = \frac{RB}{RA + 2RB}$$

Figure 2. Duty Cycle of 25%.

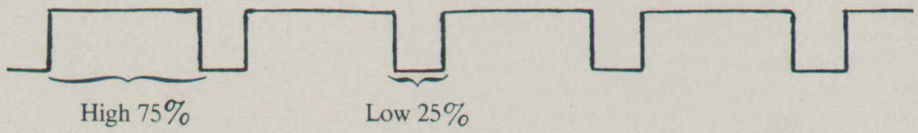


Figure 3.

Operation	Address 4K ROM	Address 8K ROM	Generates Active low signal	Comments
READ or WRITE	4096	32768	Count reset	Resets all the counters to zero.
READ only	4097	32769	Low Count EN	Reads the low order 8 bits of counter.
READ only	4098	32770	High Count EN	Reads the high order 4 bits of counter.

For example, the calculations for a counter that counts time invervals of 50 u sec (as I need) are as follows:

1) Choose 0.01 uf for the C value:

$$20 \times 10^3 \text{ Hz} = \frac{1.44}{(RA + 2RB)\ (0.01 \times 10^{6})\ \text{farads}}$$

$$RA + 2RB = 7.2 \times 10^3 = 7.2\text{K ohms}$$

2) Choose 2 resistor values such that RA + 2RB = 7.2K

I chose RA = 3.6K and RB = 1.8K

3.6K + 2(1.8K) = 7.2K

3) The duty cycle is:

$$\frac{1.8K}{7.2K} = .25$$

This means that the waveform is low for 25% of the time. It will appear similar to Figure 2.

Although not critical, for this application try to keep the duty cycle between about 10% and 90%.

The oscillator will feed the string of 74LS161 counters which will count up to the maximum count (in this case 4095) then go back to zero and automatically begin counting up again. Since the output of the counters is always active, I must place their outputs on the data line only when I want to read them. Therefore, I needed the 74LS244 buffers that are enabled onto the data bus only when their pins 1 and 19 go low. Since there are only 8 data lines, obviously all 12 bits cannot be read at once. So I needed to control the counter string in groups of 8 bits. In my design a Low Count EN signal places the low order 8 bits on the data bus, and a High Count EN places the remaining 4 high order bits on the data bus. Therefore to get the total count value, two read instructions are necessary. (See the application section below.)

Figure 5. Low order counter test.

Address	Decimal		Instruction	Comments	t States
16430	33 32 78		LD HL, 20000	START OF DISPLAY BLOCK	
16433	50 0 16		LD (4096), A	CLEAR COUNTERS	
16436	14 255		LD C, 255	DISPLAY COUNTER	
16438	58 1 16	BACK	LD A, (4097)	LOAD LOW COUNTER VALUE	t=13
16441	119		LD (HL), A	LOAD DISPLAY BLOCK	t=7
16442	6 9		LD B, 9	DELAY OF 117 t STATES	t=7
16444	16 254	AGAIN	DJNZ AGAIN		t=13
16446	35		INC HL		t=6
16447	13		DEC C		t=4
16448	194 54 64		JP NZ, BACK		t=10
16451	201		RET		

Basic program

```
10   REM (PUT IN 40 characters to
     hold machine Code)
20   LET K=USR(16430)
30   FOR I=20000 TO 20200
40   PRINT PEEK(I),
50   NEXT I
60   STOP
```

Decoding

Three memory addresses that contain nothing (no ROM or RAM) are needed to map the counters into. On the MicroAce with the 4K ROM, the memory from 4096-8193 is not used. With the 8K ROM and up to 16K RAM, the memory area above 32767 can be used. This is shown in Figure 1. Just substitute A15 for A12 in this article for use on the computers with the 8K ROM.

I wired up the 74LS138 decoder to be enabled when both the MREQ signal and the address line A12 are asserted. Note that the LS138 is disabled if A14 is asserted since this would be an address in the 16K RAM area (located at addresses 16384-32767).

Wiring pins 1, 2, and 3 of the LS138 to address lines A0, A1, and A2 gives active low signals when the addresses shown in Figure 3 are asserted. The LS138 decoder (address 4099-4111) has five more outputs that can be used for future expansion.

Since the counters free-count asynchronous to the MicroAce, we might get an inaccurate count (some bits might be at the transition between high and low) if we read the counter when the count is changing. Therefore I gated the Low Count EN and High Count EN signals with the oscillator output (LS08) to disable any counting while the counter is being read. No counts are lost because it only takes 4 μ seconds to read the counter. I also used the 74LS14 Schmitt trigger inverter to give me a sharp edge from the 556 oscillator. This was probably not needed, but, since it worked, I kept it in the circuit.

Construction

One of the major problems in adding hardware to your computer is where to put it. I had a wire-wrap prototype board to put the counter ICs on, but interfacing it to the MicroAce was a challenge. I had,

Figure 6. High order counter test.

Address	Decimal			Label	Instruction	Comments	t States
16430	33	32	78		LD HL,20000	START OF DISPLAY BLOCK	
16433	50	0	16		LD (4096),A	CLEAR COUNTERS	
16436	14	255			LD C,255	DISPLAY COUNTER	
16438	22	13		BACK	LD D,13	DELAY LOOP	t=7
16440	58	2	16		LD A,(4098)	LOAD HIGH COUNTER VALUE	t=13
16443	230	15			AND 00001111B	MASK OUT UPPER 4 BITS	t=4
16445	119				LD (HL),A	LOAD DISPLAY BLOCK	t=7
16446	6	244		AGAIN1	LD B,244		t=7
16448	16	254		AGAIN	DJNZ AGAIN	DELAY OF 41548 t STATES	t=13
16450	21				DEC D	(12.78 Msec)	t=7
16451	194	62	64		JP NZ,AGAIN1		t=10
16454	35				INC HL		t=6
16455	13				DEC C		t=4
16456	194	54	64		JP NZ,BACK		t=10
16459	201				RET		

as I am sure most of you have had, a difficult time finding a suitable edge connector for the MicroAce. Also I wanted to buffer the signals on the edge connector as close to the connector as I could to increase signal drive and reduce noise pick-up.

Therefore I built the small buffer board with 74LS244 buffers on it, wired as shown in Figure 4. This small buffer board was mounted with a spacer above the MicroAce edge connector (I drilled a small hole in the corner of the MicroAce circuit board, being careful not to drill through any circuit runs). Then I carefully soldered the connections from the buffer board to the MicroAce edge connector using short lengths of wire-wrap wire. The buffer outputs were soldered to a 37 pin D connector also mounted on the buffer board. Since D connectors are readily available, I felt this was a good choice.

So now all the edge connector signals are buffered except the 8 data lines. These are difficult to buffer because they are 2-way signals. The buffer must be steered to or from the Z80 CPU depending on whether a read or a write is being done. Since I was not sure what circuitry to put on the prototype board, I decided to buffer the data lines on the prototype board and not the small buffer board. Therefore I ran the data lines directly from the edge connector to the D connector. As it turned out, this counter circuit alone will work fine without any buffering, but, since I also added 16K RAM to my prototype board, I felt the buffering was needed. I then connected my prototype board edge connector to a mating D connector with about 10 inches of wire. This makes removal of the prototype board from any system quite easy.

Testing

So now the counter is wired up and power is applied. The prompt comes up on the screen, so I know at least the MicroAce still works (that is reassuring anyway). But how do I test the counter?

I wrote two short programs (Figures 5 and 6) that are a combination of machine code and Basic. Load in the machine code starting in location 16430 (location 16520 in 8K ROM systems). The first Basic statement should be a REM statement, long enough to hold the code then scrolled off the screen with PRINT statements.

The program in Figure 5 tests the low order 8 bits of the counter. The program resets the counter then reads the counter every 50.4 μsec, displaying the result. The display should go from 0 to 255 but will skip a number every so often since the counter counts at exactly 50 μsec but the program reads the counter every 50.4 μ sec. This was good enough for a functional test. I did not want to fine tune the program to read the counter every 50 μsec. The time a program takes can be calculated by counting the number of t states each machine code instruction takes. On the MicroAce/Sinclair, 1 t state = .308 μsec.

The program in Figure 6 checks the high order 4 bits of the counter. It resets and reads the counter every 12.808 Msec, displaying the result 200 times. The display should go from 0 to 15 and increment every 12.8 Msec. If the low order counter works but the high order counter does not, check the ENT and ENP connections (pins 7 and 10) on the high order counter.

Application

To use this counter most effectively, it is best to reset the counter at the beginning of the time interval to be measured, then read the counter at the end of the time interval. This will give you the number of 50 μsec intervals that have expired. Remember that, when the counter reaches its limit (4095), it goes back to zero and starts counting again. Therefore the time interval that you measure cannot be larger than 4096 x 50 μsec = 204.8 Msec. If it is, either change the 556 oscillator resistor values to obtain a slower frequency or add more 74LS161 counters to your circuit.

The two most convenient ways to read the counter are:

1) In machine code, load one of the register pairs, for example, HL, as follows for 4K ROM:

```
LD A,(4098) ;read high order count
LD H,A
LD A,(4097) ;read low order count
LD L,A
```

Now register pair HL contains the full 12-bit count.

2) In Basic, read in the high order count, multiply it by 256, then add it to the low order count. For example, for the 4K ROM:

```
LET A=PEEK (4098)
LET B=A*256
LET C=PEEK (4097)
LET C=PEEK (4097)
LET D=B+C
```

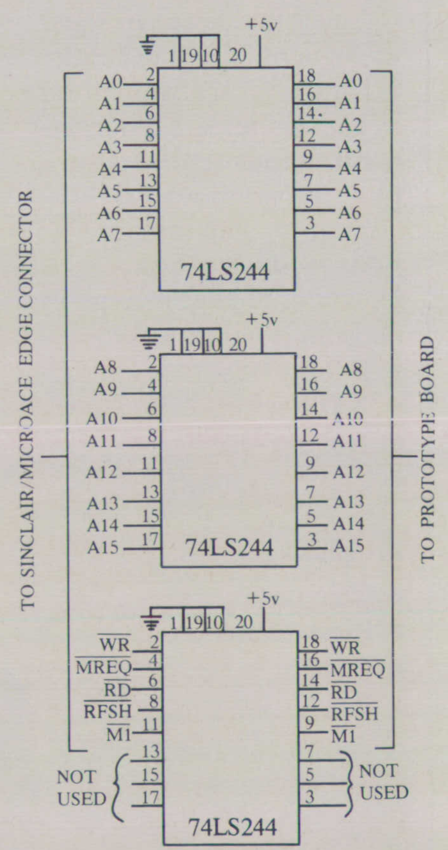
For the 8K ROM, change 4097 to 32769, and 4098 to 32770. above. The number in variable D is the full 12-bit count.

We hope that you will be able to use this hardware timer for your purposes—It can be used for anything from designing an alarm system to displaying the correct time while your program is running. Good luck in your timing applications. Now you can tell your doubting friends that computers are really smart; just look, they can count and, with a little programming, they can even tell the time!

Basic program

```
10    REM (PUT IN 40 characters to
      hold Machine Code
20    LET K=USR(16430)
30    FOR I=20000 TO 20254
40    PRINT PEEK(I)
50    NEXT I
60    STOP
```

Figure 4. Interface board.



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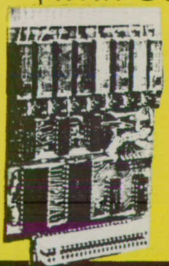

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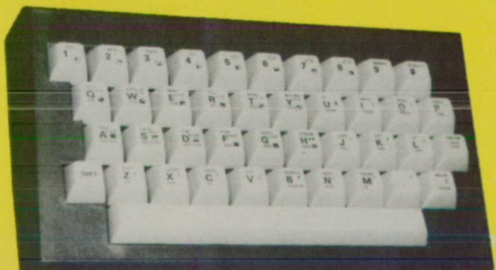

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Free Update
Current owners of *Financial Record Keeper* (16K) or *Financial Record Keeper Plus* (48K) may write for listing of newly added *Tax Deduction Review* application to flag tax deductable payments during the normal entry procedure and review them at any given time. (Note: Current cassettes being mailed incorporate this application.) Send SASE.

Home Budget Planner
16K RAM. $10.95 pp.
Computes and compares amount spent versus budget for a 13 month period. 20 user definable budget categories and 10 separate categories for income and deductions. Displays and prints out data by the month or year to date. Bar charts are drawn from monthly averages and show the year at a glance in graphic detail. Menu driven with easy edit and update.

Memotech
Memocalc
EPROM: $49.95 plus $4.95.
Spreadsheet analysis to assist with reports and financial forecasts. Performs complex number crunching routines with ease. Memopak's 64K RAM gives a table of up to 7000 numbers with up to 250 rows or 99 columns. Quick revisions. The CALCULATE command reevaluates and displays the information. Tool has been generalized to perform interactive calculations in numerical tasks. On EPROM and plugs directly into your computer.

Sikes Software
Checkmaster
16K RAM. Cassette: $16.95.
Enter and store over 450 transactions per load. Menu driven. Allows you to list, search, add, save, graph. Special graph feature allows you to graph checking balance 9 dates at a time, starting with any desired date. Search for credits, dates, and debts. Graph may be scaled and labeled as desired.

Stocks

Air Capitol Software
Call/Put Stock Options Analysis
16K RAM. Cassette: $25.
Make objective strategy decisions. Requires only current options data from popular financial publications. In-depth analysis using extension of Black-Scholes model. Nine options per run ranked by potential profit, loss, expected return. Easy-to-use; full screen edit. Documentation.

Biocal Software
(See Directory of Suppliers for prices.)
Stock. Cassette only.
Learn the mechanisms behind the stock market. Includes buying on margin, short selling, convertible preferred, options to buy via warrants. Invest.

Memory Master
Stock Analysis and Portfolio
16K RAM. Cassette: $10.95 pp.
2 programs: Program 1: Takes data on any stock, computes total cost including broker's commission, and computes the result of any number of call options entered including gain, yield, time held and more. Program 2: Holds information on up to 10 stocks and computes gain, yield, etc. Displays a composite view of all stocks held. Easily updated, changed, or deleted.

Word Processing

Bob Fingerle
Textwriter 1000
16K RAM. Cassette: $11.95; listing: $5.95.
Text editing program. Capabilities include: insert/delete, text compression/realignment, and buffer memory for saving portions of text to use elsewhere. Also includes tabulation, logically formatted display, text save, and ZX/TS printer control. SASE for free information.

Memotech
Memotext
EPROM: $49.95 plus $4.95.
Brings commercial standards of text editing to your computer. Text is first arranged in 32 character lines for the screen with comprehensive editing facilities. User chooses line length for printing and the system does the rest. Memotech printer interfaces enable output with 80 character lines, upper and lower case, single and double size characters. On EPROM and plugs directly into your computer.

Miscellaneous Programs

John Richard Coffey
Touch Type Game
2K RAM. Listing: $1 plus long SASE.
Learn to touch type all the ZX/TS symbols in a fun, challenging manner. Recommended only for users with special keyboards or overlays. Takes about 10 hours to master. All Basic. More detailed than the game that appeared in *SYNC*.

Computer Software Associates
Statistics Package
1K RAM. $12.95.
4 programs with error-correcting facilities to compute the following statistics: mean, standard deviation, variance, correlation coefficient, regression, equation, confidence interval for mean, 3 applications of the "t" test and the "F" test of the ratio between independent sample variances.

Compuwiz Software
The Educator
16K RAM. Cassette: $10.
A program to teach you all about programming your computer. All teaching is interactive and very easy to learn.

Florida Creations
Music/Sounds Package
1K RAM. Listing: $3.

5 programs and discussion for broadcasting music and spaceship noises to a nearby radio. No hardware modifications required. Controls the radio frequency interference generated by the computer.

Home Applications
Weight-Watcher
Listing: $3.

Basic program contains database of 200 foods and caloric values by portion with more than 30 common activities to compute minimum daily requirements. Compare daily consumption as a dieting aid. Program can be tailored for personal diets or food preferences. Completely menu driven.

Enjoying Your Computer: Games

Miscellaneous Games

Biocal Software
(See Directory of Suppliers for prices.)

Chase. 1K RAM.
Steer your interceptor to the target. Arrow buttons control velocity.

Flower
Display program plots ellipses in a spiral pattern. Watch as many varieties bloom.

Fvee. 1K RAM.
A road racing game. Steer your formula car to a new distance record.

Guess
2 games in 1. Hangman plus Guess the Animal. A self-learning game in which the computer questions you.

Hollywood. Cassette only.
As a movie produce you must obtain actors, script, and a director. Spending money begets money.

Life
Watch colonies of life-forms become alive, mutate, and die. Control matrix size, generations.

Meelborn. Cassette only.
Two cars race toward a 1000 mile goal. Includes flat tires, accidents, running out of gas, stop lights.

Pong. 1K RAM.
Two player pong game. Keeps score.

Quicksand
You are traveling through a forest and must detour through a swamp. Can you avoid the quicksand pits?

Race. 2K RAM.
A road race game. Can you break the distance record?

Roadrace
Steer a Formula-1 car through a tough road course. Different track each time.

Secrets
Cryptographers. Code/decode messages with a keyword generated cipher.

Shark-Hunt
Chase a man-eating shark; trap it in your nets; avoid the rocks, old tires, and other snags.

Snare
Corral a wild stallion. Try to encircle him in the minimum number of moves.

Tower. 1K RAM.
Guessing game. Code demonstrates poking the internal display file.

War
Inverse video graphics display program which plots a multiplayer card game.

Worm
Graphic display program. Plots a worm's path as it searches for entry into the ground.

Computer Software Associates
Towers Of Brahama
1K RAM. $9.95.
Challenges your skill and manipulation. There are 3 posts on the screen. Your starting base contains 5 disks stacked in ascending order by size. The remaining 2 are parking bases. To win this game, you must park the 5 disks on the third post in an ascending order.

Bulls and Cows
1K RAM. $9.95.
A game of concentration for all ages! The computer randomly chooses 4 numbers. You must decipher the "master set" exactly. When you enter your guesses, the computer will tell you how many of the chosen numbers match the set, and how many match in exact order.

Nim
16K RAM. $9.95.
The first player chooses a number of matches and arranges them in 3 piles. The second player then chooses a pile and removes some matches. The first player then removes some matches. Any number of matches may be removed from any pile. The winner is the person (or computer) who removes the very last match. 4 levels of difficulty.

Four in a Row
16K RAM. $14.95.
A game for 2 or more players on a vertical board with 8 columns and 8 rows. The object is to get 4 pieces in a row: horizontally, vertically, or diagonally. Players alternate turns until a win is achieved.

Slides and Ladders
16K RAM. $14.95.
Up to 4 players. Each player begins in the cellar of a mansion and must work his way through 40 rooms. The player to reach the 40th room first is the winner.

Mugsy
16K RAM. $9.95.
You are the Boss of a Chicago gang operating a protection racket. Can you survive the rival gangs, the cops, and Nick the Greek?

Intercomputer Inc.
Hopper (1017)
16K RAM. $12.95.
Can you help Fergy and his friends get across the highway and back to the lily pond? Includes crocodiles, logs, varying speed traffic, etc.

Memory Master
Code Master
16K RAM. $10.95 pp.
Menu allows 3 choices: 1) solve cryptoquotes stored in memory; 2) have the computer generate a code from material typed in by the user; or 3) solve a code from a newspaper, etc. Options 1 and 2 offer 3 different types of code, each with a different level of difficulty. A cursor controlled control panel is used for letter replacement. Hint and quit routines make it easy enough for a 10 year old to master but hard enough for the avid puzzle fan.

MicroSync Software
Air Traffic
2K RAM. Cassette: $4 plus $1 s&h; listing: $2 plus SASE.
Try to dodge the oncoming planes and buildings. Many levels of play. Keeps score. Fast action.

Praise Data Systems
Bible Quiz Games
16K RAM. Cassette: $10.95 pp.
A series of games to test your knowledge of Bible Scripture. Interesting and educational fun for the whole family. Keeps score for you so that you can see your progress as you play again. SASE for list of programs.

SyncWare Co.
Storm Lander
16K RAM. $9.95.
Make an emergency landing at Denver's Stapleton Airport in your commercial airliner, during a thunderstorm. Three screens of graphics show your progress in avoiding storm clouds, other aircraft, mountains, and downtown Denver, while homing in on navigation beams for a safe descent to the runway and finally taxiing to the terminal.

Miner's Revenge
16K RAM. $9.95.
Get fabulously rich if you crack the motherload. The old miner's last will, will help you on the way, equipped with a pick-axe, flares, spikes, and a lantern. The 9 markers left by the old miner will guide you to the big vein, but watch out for falls that cause the loss of time and tools. Not a text adventure game; continuous full screen graphics for improved realism.

Super Slide
16K RAM. $9.95.
You are in the 1988 Olympics bobsled event. Pick up points while avoiding skid-patches, walls, ruts, and the course boundary. If you pass the qualifying run, you compete in two heats. Your score on both runs places your final position in a field of over 80 competitors. You must be very good to win the gold medal. Practice in the DEMO mode, which continually cycles a new course. Machine code action.

Sikes Software
Mega-tron
16K RAM. Cassette: $14.95.
Try to destroy the computer light cycle. Avoid

hitting the light trails left behind the cycles, the walls of the game grid, and the cycles themselves. On screen scoring and bonus cycles. Machine Code.

Skelly Computing
Guess It
16K RAM. Cassette: $3 plus $1 s&h; listing: $1 plus SASE.

A number game with 3 levels of play and prompting.

2-Bit Software
Working Mother's Dilemma
2K RAM. Cassette: $14.95.

Package of 4 games: Designed as a fun way for women to learn about computers: Mad Dash: Tests your ability to race through the house when you have not had a break all day. Carfool: Figure out how to use the least amount of gas while running errands all over town. Harried Housewife: Adventure game that rewards you with a hot bath and a nap after a hectic day that includes a dazed search for your car in the parking lot of Shopping Mall.

Shoot 'em Up Games

Biocal Software
(See Directory of Suppliers for prices.)
6-Shooter

A game of skill in which you try to hit a randomly moving target. 5 levels of difficulty.

Artillery

Protect your hometown from enemy planes. Variable gun angles, limited ammo, so aim carefully.

Bomber

Maneuver your bomber through anti-aircraft flak to drop your payload over the target; fuel limit.

Dogfight

Shoot down the enemy planes before they destroy your 5 planes. Fuel and ammo limits.

Sniper. 1K RAM.

A randomly moving target pops in and out of view. Hit it before it disappears.

Wolfpack

You are the commander of a Navy destroyer searching for enemy submarines. Depth charges ready.

Computer Software Associates
Murgatroyds Revenge
16K RAM. $14.95.

The fiendish Murgatroyds are on the warpath again! You must fight off their attack with mines, superglue, decoys and more.

Robot Tanks
16K RAM. $14.95.

The battle has gone poorly. Enemy tanks have you surrounded with an unlimited supply of ammunition. You have one shot left. After you have fired your final round, your tank will become immobile. Your only source of defense is to lure your enemies into shooting one another. Good luck! Save your last shot to win!

MicroSync Software
Bomber
2K RAM. Cassette: $3 plus $1 s&h, listing: $1 plus SASE.

A target practice game in which you try to hit a target on the bottom of the screen. 2 types of missiles, one bomb. Target explodes when hit.

Robert J. Midura
Strategy at Sea
16K RAM. Cassette: $10.

2 games. Convoy: Shooting gallery type game; your sub has 20 missiles to attack a 15 ship convoy; targets pass in either direction at various distances from your sub; graphic explosions; 5 levels of play; 5 types of ships; score shows all ships sunk. Sub Hunt: Your destroyer must track down and sink 5 nearly invisible subs before they sink your 5 fleet ships or your destoyer; watch out for mines and collisions with your own ships; graphics display of ocean grid, fleet ships, mines, depth charges, and explosions.

Space Games

Biocal Software
(See Directory of Suppliers for prices.)
Cruiser

Navigate your spaceship through a meteor storm. How far can you travel without damage?

Orbit

Maneuver your spaceship into an inner orbit to pick up your cargo.

Treasure

Collect the treasure before the alien robot catches you with its radar tracking system.

Computer Software Associates
Galactic Patrol
16K RAM. $14.95.

Your 6 year mission is to explore new worlds, to go where no being has gone before! Your job, as captain of the *Galactic*, is to protect the lives of the 500 aboard and to operate the bridge.

Super Invaders
16K RAM. $14.95.

Negotiations have ended. Now comes a show of strength. "The Earth is being invaded!" All beings on Earth are depending on you. Don't let us down!

Intercomputer Inc.
Arcade Games (FG1016)
16K RAM. $12.95.

In any other time or galaxy, the dust ball of the world called Tai would have been quite unimportant. Time changes and the entire civilization will be betrayed. You have been chosen to defend Tai. The galactic future depends on you.

Memory Master
Spaceflash
16K RAM. $10.95 pp.

Earn shots at an alien landing craft by successfully answering questions in various drills. 3 levels of drill in addition, subtraction, multiplication, division, and visual memory training. Complete scoring for drills and space game. The visual memory drill automatically increases in difficulty as the player gives correct responses.

Tarbon's Revenge
16K RAM. $10.95 pp.

An enhanced version of *Spaceflash*. Position your space ship to intercept the alien with one of your missiles. Select the number of ships that must be shot down to win and the number of ships Tarbon must land to conquer the earth. As your aim gets better, Tarbon makes it more difficult by sending down smaller ships.

MicroSync Software
Galaxy Master
1K RAM. Cassette: $4 plus $1 s&h.

Fight the aliens on the top; watch out for the bombs that they drop. 3 levels of play. Machine code.

Sikes Software
Moon Mission
16K RAM. Cassette: $14.95.

Land your space craft safely on one of the 4 launch pads. Features: Full graphics display of mountain terrain, launch pads, and lunar cities. Instrument panel assists you in landing safely. Machine code.

Invaders
16K RAM. Cassette: $12.95.

Shoot down the marching aliens with your rapid fire laser cannon before they take over the planet forever. Shields are provided for protection against the aliens' bombs. Machine code.

Casino Games

Biocal Software
(See Directory of Suppliers for prices.)
Blackjack

Multi-player, multi-deck version of popular 21 card game. Sharpen your skills for Las Vegas/Reno.

Bong

Throw dice until you reach 10,000 points. 1's and 5's are scoring dice. Up to 5 players.

Craps

Bet on the dice rolls. Up to 5 people.

Solitaire

Las Vegas version. Standout layout is dealt with remaining deck dealt face up over last 6 columns.

Compuwiz Software
Casino Fun
16K RAM. Cassette: $10.

This very comprehensive Blackjack game follows full casino rules such as double down, split a hand, etc. Hi-lo is derived from the popular English game. Excellent graphic displays are used in both games. Watch the "chips" go up and down as your winnings fluctuate!

Casino Fun II
16K RAM. Cassette: $10.

Play the exciting game of Baccarat as it is played in European casinos. Graphics display of cards, messages, and chips. Memory challenges and develops your ability to recollect. For all ages.

Sikes Software
Blackjack
16K RAM. Cassette: $9.95.
Casino blackjack at its best. Take your $500 bankroll and put your luck to the test. Full graphics display of cards makes this game fun and exciting.

Maze Games

Biocal Software
(See Directory of Suppliers for prices.)
Amazing
Can the mouse reach the cheese before that cat catches it? Watch the mouse travel through the maze.

Catnmouse
Two cats chase a mouse through a maze. You control the mouse to score on its way to the cheese.

Maze. 1K RAM.
Shifting maze. Prints random maze.

Computer Software Associates
Mazeman
16K RAM. $14.95.
Mazeman scours the maze for food while dodging ghosts which are trying to devour him. Are you capable of beating the high score before Mazeman is devoured?

Sikes Software
Micromaze
16K RAM. Cassette: $16.95.
Eat the dots and score points while evading the deadly Drone; 11 automated levels of play, so the better you play, the better this game gets. Almost unbeatable. Machine code.

Other Games on the Computer

Biocal Software
(See Directory of Suppliers for prices.)
3DTTT. Cassette only.
Challenge the computer in a game of Tic-Tac-Toe. Played in 3 dimensions on a 4 by 4 by 4 grid.

8-Ball
Call your stroke, cue-angle, and object ball angle. The computer calculates all subsequent angles.

BCKGMN
Challenge the computer, play against another player, or watch the computer play both sides.

Checkers
Challenge the computer to a game; includes demo game and two player mode.

Cube-Sym
Rubik's cube simulator. Use any size cube. How many moves will you take to solve it? With scramble.

Stuart Software
Pick 'em
16K RAM. Cassette: $14.95 plus $2 s&h.
Predicts the outcome of NFL games with point spread.

NBA Picks
16K RAM. Cassette: $14.95 plus $2 s&h.
Predicts the outcome of NBA games with point spread.

SyncWare Co
NFLX Football
16K RAM. $9.95.
Provides a full-featured football contest for one or two players. Not a "text" game. Safeties, interceptions, runs, passes, punts, fumbles, and field goals are displayed with machine code graphics. Defensive plays include Blitz, Red Dog, Normal, and Prevent. Includes demo option to continually demonstrate pass and running plays.

Game Collections

Charles J. Bonner
Flight Simulations
2K RAM. Cassette: $12.95.
4 flight programs; some with graphics. Guide a parachute to a target; fly a biplane over a mountain range; fly a jet airliner across the Pacific Ocean; navigate a spaceship from the Asteroid Belt to Earth orbit.

Computer Software Associates
1K Games. $19.95.
5 games: Duck Shoot: All the excitement of duck hunting, without getting up at 4 a.m. Moon Lander: If you thought Neil Armstrong had it easy, this is your turn to try to land on the Moon. Hangman: 1 or 2 players; sharpen your spelling skills. Crossword: Challenging, mind-boggling word association. Letter Square: Arrange the alphabet in correct order.

Compuwiz Software
Arcade Fun
16K RAM. Cassette: $10.
3 games: Arcade type; moving graphics. Escape: Get as many points as possible before the closing walls crush you. Snake: Devour points, leaving a trail over which you cannot cross. Trap: Two players are set against each other.

2K Game Pack
2K RAM. Cassette: $10.
5 programs: Kaleidoscope: Dazzles you with super displays. Over Under and Remember: Two challenging and thought provoking card games. Reverse: Explore your skills in logical thinking. Sketch: Let your imagination run wild and become an artist.

Mind Benders
16K RAM. Cassette: $10.
3 thinking games: Master Mind: An exciting version of the popular board game. Super Mind: A tougher version for those who enjoy a real challenge. Guess: An enjoyable number guessing game. All games use full screen graphics.

Florida Creations
Fun and Games Package
1K RAM. Listing: $1 plus SASE.
2K RAM. Cassette: $9.95 plus $1 s&h.
3 programs: Draw: Draw and sketch whatever you want; automatic erase; flashing cursor. Lunar Lander: Land you LEM on the landing pad without blowing up; horizontal and vertical velocities; fuel. Secret Code: Converts your messages into an unintelligible string of alphanumeric characters and back into English.

NO MORE BAD CASSETTE LOADS with THE Z-DUBBER

The frustration of trying to load a cassette program into your Sinclair ZX80/81 or Timex 1000, is this what you really bought your computer for? **Why put up with it? Now you don't have to.** The Z-Dubber is a small device which connects between your computer and cassette player, improving your loading ease 100%.

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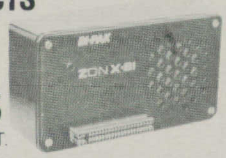

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- No power pack, batteries, leads or other extras.*
- Manual Volume Control on panel — ample volume from built-in loud-speaker.
- Standard Sinclair — 16K Rampack or printer can be plugged into ZONX Sound Unit without affecting normal computer operation.
- Huge range of possible sounds for Games, Music, Helicopters, Sci-Fi, Space Invaders, Explosions, Gun-shots, Drums, Planes, Lasers, Organs, Bells, Tunes, Chords, etc., or whatever you devise!
- 8 full octaves. Uses 3-Channel sound chip giving programme control of pitch, volume of tones and noise, all with envelope control.
- Easily added to existing games or programs using a few simple "BASIC" lines or machine code.
- No memory addresses used — I.O. mapped.

FULL instructions with many examples of how to obtain effects and the programmes, supplied. Fully guaranteed. British Made.

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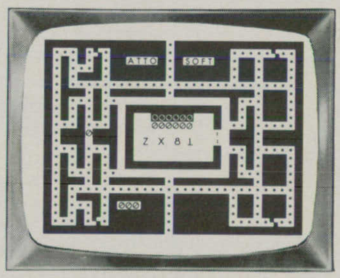

ZX-MAN

Turn your **ZX81** or **TIMEX SINCLAIR 1000** into an arcade type game computer with **ZX-MAN.** 100% machine code makes this fast acting program as much fun as being at the arcades. With the joystick option you can have the real feel of game playing never before available for your **ZX81** or **TIMEX SINCLAIR 1000.** **16K required...... $14.95**

JOYSTICK and ZX-MAN-Both for $24.95

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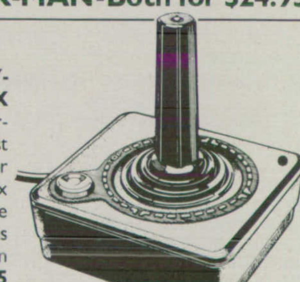

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SyncWare Co.
Fun and Games I
2K RAM. $9.95.

5 games: Bring those TS1000s out of the closet. Included are Syncwars, Minotaur, Nim, ContsEntration, and TS Doodle, combining 2 older Basic games with 3 new ones in a "something-for-everyone" package.

ZXSystems Software
ZX-Pack
1K-16K RAM. Cassette: $16.99 plus $1.50 s&h.

9 games and programs: Ranging from 4Dict-tactoe to ZX-Probe and a savings account balance computing program. Instructions.

Horse Racing

CRC Software
Horse Master
16K RAM. Cassette: $12.95.

Before you go to the track...consult with the Horse Master! Your racing form or local newspaper gives you the date, and this program will help you analyze it!

A. Doty
Horse Racing Handicapping
16K RAM. Cassette: $12.50 pp.

Analyses thoroughbred races giving critical handicapping parameters for each horse. Based upon statistical methods by using key past performance information to aid in predicting potential winners. Instruction pamphlet.

M. H. Marks Enterprises
Handicapper
16K RAM. Cassette: $9.95.

This program will help the horse racing fan make more intelligent decisions at the wagering window. After pertinent data obtained from standard racing programs is entered, the computer assigns appropriate "points" to each parameter based on a weighted system and a display of the percentage of "chance to win" of each horse in the field.

3G Company, Inc.
Horse Race Handicapping Program
16K RAM. Cassette: $24.95.

This is a scientifically derived system for calculating odds on horse racs. Hundreds of races were analyzed and numerical probabilities computed to form the basis of this program.

UAS
Flat Racing. (C6001).
16K RAM. Cassette: $12.95.

Handicap the thorobred horses on any track. Input data from the facing form and find the racing form and find the potential winner. The program follows the proven concepts used by the *Win-rator* to find the most probable winner.

Hangman

American Micro Products, Inc.
Hangman
16K RAM. Cassette: $17.95.

A computerized version of the classic children's game of Hangman. Preprogrammed with 235 words; however, the user can replace these with more than 500 words.

Computer Software Associates
Lynchmob
16K RAM. $12.95.

A competitive game of skill and strategy for 2-6 players developed from the traditional game of Hangman. Picks turns, keeps scores, and lynches the losers in animated graphics.

Gladstone
Hangman (Z78)
16K RAM. Cassette: $9.95.

2 games. Movies: Over 100 titles and film stars; 3 categories. Superheroes: Names and their arch-enemies.

Haymarket Software
Haymarket Hangman
16K RAM. Cassette: $9.95.

5 categories with instructions on how to change the category names to suit individual needs. Each category contains up to 50 words and the computer even adds the words you use when playing with two players. In effect, the computer learns. Increase your children's vocabularies or just put in their spelling list.

R. Midura
Hangman
16K RAM. Cassette: $10.

Features a graphics display, a scratch sheet display to keep track of letters guessed, 7 word categories, score keeping, and 400 word dictionary (prerecorded dictionary: animals, vegetables/fruits/herbs, music, astronomy, birds, automobiles, and geography). Create your own dictionary.

Softsync, Inc.
Hangman
16K RAM. Cassette: $14.95.

A learning tool to tutor children (ages 6-12) in spelling. Seven versions of Hangman. Play against the computer's five prerecorded libraries of categorized words (each word up to 17 letters): animals, science, countries of the world, states of America, and fruits and vegetables. Create your own library of 500 words.

Z-West
Hangman
16K RAM. Cassette: $4.95 plus $1 s&h.

The computer becomes a very special vocabulary tutor in this traditional game of Hangman. Discover the unknown word before you are hanged! 5 levels of play with 5 words in each level.

Golf

Asia Tsusho Co., Ltd.
Golf Game
16K RAM. Cassette: $14.

A full scale golf simulation game of 18 holes by adopting the table of random numbers system. By inputting in sequence CLUB SELECT, DIRECTION, STRENGTH, you can enjoy your golf game with green scenery varied from time to time.

Biocal Software
(See Directory of Suppliers for prices.)
Golf. 1K RAM.

Get your clubs out and play a few holes. Good for judging distances.

Computronics
ZX Open
16K RAM. Cassette: $16.95.

Simulates golf on 5240 yard, par 71, 18 hole course. Select driver, irons, pitching wedge, or putter. Holes, slices, or misses the ball. Sand, water, or lost in the trees. Up to 4 players. Automatic score card.

Emvee Software
Mini-Golf
16K RAM. Listing: $6.

Play 9 or 18 holes against another player or the computer. The better your practicing performance, the better your practicing performance, the more consistent your play will become. A different course for each round played.

R. Midura
18 Hole Golf
16K RAM. Cassette: $10.

Features a graphics display of each hole, animated ball, 3 types of hazards, 5 player capability, and final score card display. Hazards include bunkers, water traps, and trees. The display of each hole lists hole number, par, current shot, current score, and name of player. 9 different courses available.

Minigolf
16K RAM. Cassette: $10.

Graphics display and random creation of each of the 18 holes; random height of elevated tee; 3 types of variable size hazards; animated ball; splash effect; final score report. Also displays hole number, hole par, shot number, and current score. Distance between tee and hole determines par. Flashing messages for misses and hole in one's. Can play either same course or a new random course. 9 levels of difficulty.

Supplements for 18 Hole Golf
16K RAM. Cassette: $10.

Courses 4, 5, 6 on one cassette; 7, 8, 9 on one cassette. Courses 8 and 9 feature unlabeled graphics terrain items and more complex holes. Courses 8 and 9 offer more terrain items per hole and are recommended for advanced players.

Mindware Inc.
From Eagle Sales
Graphic Golf
16K RAM. Cassette: $9.95 plus s&h.

A full 18 hole, championship golf course. You face a brand new set of hazards each time you tee up: trees, bunkers, and gusts of wind. Make a choice of club (wood, iron, putter) and strength of choice. You also aim the shot. We do not promise that you will take the British Open, but you will test your skill and judgment. By Silversoft.

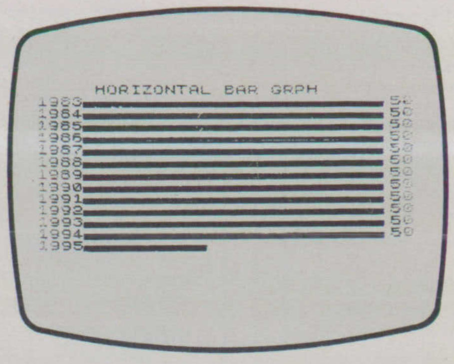
Sean Wilson
Golf
16K RAM. Cassette: $10.

Play golf with a full view of the course; nine hole course; close up of green for your putt. Superb graphics. For one or two players.

8K/16K ZX-81/TS-1000

Just for Fun, continued...

impressive but require more programming expertise, as anyone who has tried to combine the relationships of PLOT, PRINT AT, or TAB can testify.

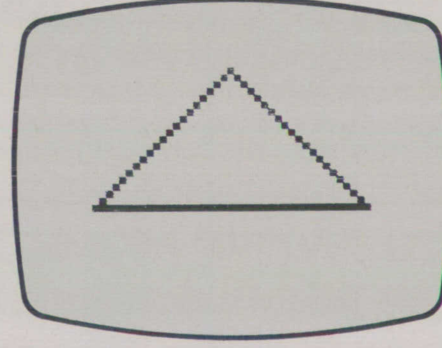


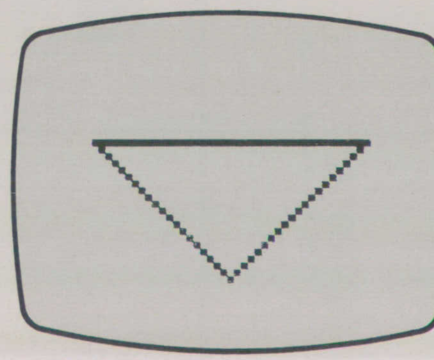
The program cannot produce a complete screen of full bars with only 1K, but if the data is not 50 each time, the program can be used with only 1K. To get the most out the program, the prompts can be shortened (or even omitted) and line 10 can be deleted. Users with 2K need not worry about memory because the program and display is well under 2K.

Isosceles Triangle

Michael W. Schultz

This program will draw an isosceles triangle, which is any triangle with two equal sides and two equal angles. This is done by drawing the base of the triangle (lines 20-50) and then two ragged lines starting at a fixed point and ending at each end of the base (lines 60-100). These





lines are the equal ones and they form two equal angles at the base.

Enter the program in Listing 1. Hit RUN and ENTER in the SLOW or FAST mode. To draw an inverted isosceles triangle make the changes given in Listing 2.

Listing 1.

```
 10 REM "ISOSCELES TRIANGLE"
 15 REM DRAW THE BASE
 30 FOR X=10 TO 50
 40 PLOT X,10
 50 NEXT X
 55 REM DRAW EACH SIDE TOGETHER
 60 FOR Y=30 TO 10 STEP -1
 80 PLOT Y,Y
 90 PLOT 60-Y,Y
100 NEXT Y
```

Listing 2.

```
 40 PLOT X,30
 60 FOR Y=10 TO 30
 80 PLOT Y+20,Y
 90 PLOT Y,Y-40
```

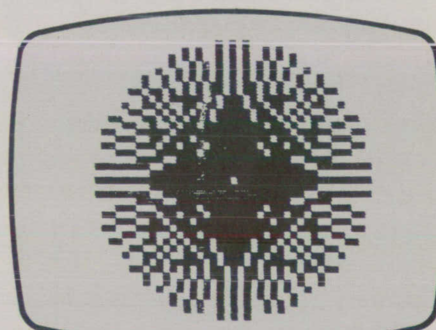
Mandalas

Randy Adams

Type in this short program. It should be RUN in FAST mode. Input values such as 8, 10, 11, 13, 14, 16, 22, 26, 28, 31, 34, 35, 38, 44, 46, 47, 50, etc. Any value from 1 to 100 will work, but not all of them will produce symmetrical figures. Try numbers 31, 32, 35, 38, and 26.

Randy Adams, 262 Edgrace Lane, Santa Cruz, CA 95062.


```
  5 INPUT Z
  7 CLS
 10 FOR B=1 TO 20
 15 FOR N=1 TO 2*Z
 20 PLOT 31-B*COS (N/Z*PI),22-B
*SIN (N/Z*PI)
 25 NEXT N
 30 NEXT B
```



Name Program

Jody Koenig

This program demonstrates a cute trick which can be turned into a very useful and effective teaching program with a few additional lines. To use the program, simply type in the program in Listing 1, put your computer into SLOW mode, and press RUN and ENTER. Add the lines in Listing 2 for a spelling aid. With the addition, you can input a word and go through it one letter at a time by pressing ENTER. The inverse letter makes it easy

Continued on page 118.

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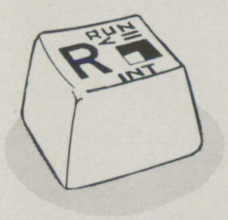

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to see how a word is spelled, and it is especially effective with young children.

Listing 1.

```
10 PRINT "INPUT YOUR NAME"
20 INPUT A$
30 CLS
40 LET A$(1)=CHR$ ((CODE A$(1)
)+128)
45 PRINT AT 10,5;A$
50 FOR F=2 TO LEN A$
60 LET A$(F-1)=CHR$ ((CODE A$(
F-1))-128)
70 LET A$(F)=CHR$ ((CODE A$(F)
)+128)
80 PRINT AT 10,5;A$
90 NEXT F
100 LET A$(LEN A$)=CHR$ ((CODE
A$(LEN A$))-128)
110 GOTO 35
```

Listing 2.

```
35 PRINT AT 10,5;A$
42 INPUT U$
75 INPUT U$
105 INPUT U$
```

Jody Koenig, 1005 Mechanic Street, Decorah, IA 52101.

Glitchoidz Report

A Machine Code Graphics Line-Drawing Subroutine, 2:6.

Listing 3: Delete one INC HL at address 40A1H

Listing 6: Insert equals signs between the letters and numbers in the LET statements.

Making Backups for Machine Language Tapes, 3:1.

Section 2. Copying with PEEK and POKE.

The second paragraph should begin: PRINT PEEK 16388+256*PRINT PEEK 16389 . . .

In the third paragraph the SAVE directions should read: To SAVE, enter GOTO 370 . . .

A Small Business Payroll Program, 3:2.

Add to the menu routines the marital status options: 1—single; 2—married; 3—head of household.

Math Support for Your ZX81, 3:2.

The alternate lines referred to in the last paragraph are:

870 INPUT A$
880 IF A$="" THEN GOTO 910
890 INPUT B$
900 GOTO 800
910 CLS
920 RUN

To superimpose graphs, add:

810 FOR X=-W TO W
830 INPUT Y

To improve response to the menu:

40 LET A=VAL INKEY$*150
50 CLS
60 GOTO A

Minotaur, 3:2.

Enter the list of variables in the immediate mode (i.e., without line numbers; e.g., LET A=1). A through I=1; J=512; K=16396; L=33; O=0; P=1; Q=2; R=3; S=5; T=20; U=31; V=128. Check by pressing PRINT (variable letter) and ENTER. Do not use RUN or CLEAR since these wipe out the variables.

To start type GOTO P; when the cursor appears, enter the density (0-1; try .35). To restart at the same density, type GOTO T. To set up the same maze again, press BREAK (except when entering density), type in RAND n (n = a number from 1 to 16535). Use the same number to repeat the maze. After the RAND command, type GOTO T to start. At density .35, RAND 19, RAND 20, and RAND 40 produce challenging mazes. The author would appreciate reports of "good numbers"; be sure to include the density setting.

Knowing Your Strengths, 3:2.

The author comments:

One of your astute readers in translating the program into TRS-80 Basic caught an unnecessary negative and a flow error which gives spurious results when attempting to RECALCulate new section or material sections. Make the following corrections:

Changes:

1545 IF N=4 THEN GOTO 2050
2140 LET S2=(W*L)/6*Z)

1545 corrects the flow and 2140 eliminates the unnecessary negative.

Add:

3005 IF N=4 THEN GOTO 3020
3035 IF N=4 THEN GOTO 3050
3075 IF N=4 THEN GOTO 3090

These skip the W, L, and X1 inputs.

Eliminating the printout (line 1622) will save screen space.

To eliminate unnecessary, screen consuming decimal places change:

3505 PRINT ". . . PT.)="; INT S2;"#PSI"

Some additional output I have found helpful:

3515 PRINT "STRESS="; INT (100/(S/32));"#PCT. OF YIELD"

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